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# Presenting an expert system for early diagnosis of gastrointestinal diseases

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**Abstract**
The gastrointestinal tract works by taking food, mechanically destroying, digesting, absorbing and disposing of undigested substances. For many gastrointestinal specialists, it is the second-largest human brain because it affects other organs and plays an important role in strengthening the body's immune system. Due to the importance of the gastrointestinal tract and its direct relationship with human daily life, timely diagnosis of this disease has a major role in the treatment and improvement of human beings. Major developments in diagnostic techniques during the past years have led to this update about indications for assortment and performance of currently available tests. So, this article presents an expert system for diagnosing the type of gastrointestinal disease and determining the type of tests needed to definitively diagnose the disease. The outputs of the expert system are designed according to the patient's symptoms. The VP-Expert shell is used to design this expert system. The results show that the designed expert system can be useful in cases where immediate access to the expert is not possible.

**Keywords:** gastrointestinal tract, expert system, disease diagnosis, type of test, VP-Expert

## 1. Introduction
Expert systems are programs that mimic the behavior of an expert in a field. These applications use the information that the user stores intending to express an opinion on a topic. Thus, expert systems continue to ask the user if they can find a topic that matches the given answers. These systems solve problems in a specific field using the rules used by professionals. Nowadays expert systems in a variety of fields including medicine, accounting, process control, human resources, financial services, GIS, archeology as well as legal advice, advice on choosing the best architecture or computer system combination and building engineering consulting are used.

## 2. Literature Review
One of the most important applications of expert systems is in the medical field, especially in the diagnosis of diseases. The eaten foods are not consumed in the same way in the body. It should go through the liver and after absorption, it starting to the blood. In doing so, the liver plays an important role in the storage of eaten substances. One of the efforts made in this field is to provide an expert system for the diagnosis of liver diseases [1]. Kidneys are organs of the body which their function is essential for life too. In the recently published paper, an expert system is presented for the diagnosis and treatment of nephrolithiasis [2]. Meanwhile, other medical expert system studies are an expert system for diagnosis of bone diseases [3], designing an expert system for suggesting the blood cancer treatment system [4], and other useful references about the expert system [5, 6, 7]. Evaluating another deadly disease such as heart disease plays an important role too [8]. Data Envelopment Analysis (DEA) provides a relative efficiency for each Decision-Making Units (DMU) with numerous inputs and outputs [9]. As a result of inherent fuzziness and uncertainties in medical practice, the compensations provided by fuzzy logic for dealing with inexact and uncertainty situation, makes it suitable approach to overcome these multiplexes in the medical data [10, 11]. Turbulences of the stomach and duodenal motor purposes are common, and the normal use of gastrointestinal researches is a significant method to find the diagnosis and to guide treatment in such patients [12]. Finally, in a review paper, a wide- ranging study of medical expert systems for the diagnosis of numerous diseases are presented. It provides a brief overview of medical diagnostic expert systems and presents an analysis of already existing studies [13].

Given the digestive system, no one can deny the importance of having a good digestive tract. Meanwhile, it can be useful in cases where the expert can assist in determining and administering the required tests. Consequently, due to various digestive tract diseases, there is a critical requirement for an expert system that can be used to diagnose the type of gastrointestinal disease, especially in poor areas before accessing the doctor. Therefore, in this article, different diseases of the human gastrointestinal tract are studied at the first step and then with the help of VP-Expert shell an expert system is designed to diagnose the type of gastrointestinal disease.

## 3. Methodology
### 3.1 Digestive System
The gastrointestinal tract (Fig. 1) consists of the gastrointestinal tract and its associated organs. The gastrointestinal tract is a tube about 7 meters long that food passes through it. It consists of the mouth, throat, esophagus, stomach, small intestine, colon, and anus. The gastrointestinal organs associated with this duct include salivary glands, liver, pancreas, and biliary tract. The gastrointestinal tract consists of a series of hollow organs, including the mouth, esophagus, stomach, small and large intestines, and anus, which have muscle walls that rhythmically move food along the intestinal tract and (as appropriate), Crushed, decomposed or mixed with digestive extracts and finally excreted. Food movement through the

gastrointestinal tract is caused by a sequence of muscular contractions called smoky movements or maggot peristalsis. The muscle wall located in front of the ingested portion contracts and pushes the food down the digestive tract. At this point, the muscle is expanding. Other types of muscle stimulate the stomach and cause stools in the colon. Gastrointestinal muscle activity is controlled by a network of nerves that cover the duct. Multiple muscle valves control the passage of food and prevent it from coming back. Different parts of the gastrointestinal tract in humans are: Mouth, esophagus, and stomach, small (small) and large intestine, liver, gallbladder, pancreas.

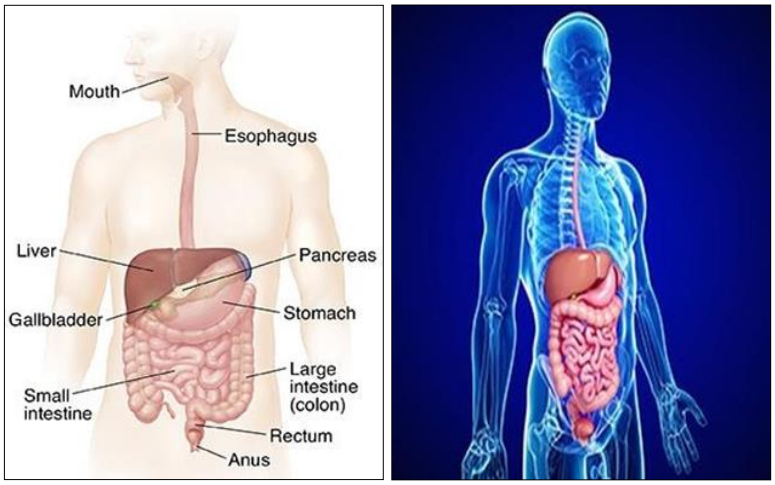


**Fig 1:** Digestive System

### 3.2 Gastrointestinal Diseases

Most gastrointestinal illnesses and problems cause short-term symptoms such as indigestion, diarrhea, and constipation. But sometimes there are long-term symptoms that indicate a more serious underlying disease. The major diseases of the human gastrointestinal tract, along with their symptoms, as well as the tests necessary for the definitive diagnosis of the disease are as follows:

**Table 1:** Symptoms and major tests needed to diagnose gastrointestinal diseases

| Number | Required tests for final diagnosis | Symptoms | The name of the disease |
|---|---|---|---|
| 1 | Stool test | 1. Diarrhea without bleeding<br>2. Natural nausea and vomiting 3- Headache<br>3. Fever<br>4. Abdominal pain in the central part | Viral gastroenteritis |
| 2 | Stool test | 1. Diarrhea without bleeding<br>2. Natural nausea and vomiting<br>3. Fever<br>4. Abdominal pain in the central part | Food poisoning |
| 3 | 1. Barium swallowing radiography<br>2. Manometry<br>3. Chest CT scan<br>4. Esophageal endoscopy | 1. The problem of swallowing<br>2. Refuse undigested food from the stomach to the esophagus<br>3. Cough<br>4. Weight Loss | Achalasia |
| 4 | 1. Chest radiography<br>2. Barium swallowing radiography<br>3. Endoscopy<br>4. Sampling | 1. The problem of swallowing<br>2. Weight Loss | Esophageal cancer |
| 5 | 1. Upper gastrointestinal endoscopy<br>2. Sampling 3-Blood test 4- Stool test<br>5- Testing for the presence of H. pylori | 1. Abdominal pain in the upper part 2- Flatulence<br>2. Belching<br>3. Natural and black temperament | Gastritis |
| 6 | 1. Blood test<br>2. Upper gastrointestinal endoscopy<br>3. Sampling<br>4. Stool test<br>5. Barium swallowing radiography<br>6. CT scan | 1. Weight Loss<br>2. Anorexia<br>3. Abdominal pain in the upper or lower left quadrant<br>4. Natural nausea or vomiting only | Gastric cancer |
| 7 | 1. Sonography<br>2. Laparoscopy<br>3. MRI for liver<br>4. CT scan<br>5. Sampling | 1. Anorexia<br>2. Fatigue<br>3. Only nausea or vomiting<br>4. Weight Loss | Cirrhosis of the liver |
| 8 | 1. Blood serum test<br>2. 2- Laparoscopy<br>3. Liver biopsy<br>4. CT scan | 1. Bumps on right side of abdomen and ribs<br>2. Abdominal pain in the upper right quadrant<br>3. Weight loss<br>4. Anorexia | Liver cancer |

| | | | |
|---|---|---|---|
| | 5. MRI<br>6. Liver ultrasound | 5. Jaundice | |
| 9 | 1. Blood bilirubin test<br>2. Liver function test<br>3. CT scan<br>4. MRI<br>5. Pert scan<br>6. Liver sonography | 1. A background of non-liver cancer<br>2. Weight loss<br>3. Anorexia<br>4. Jaundice<br>5. Abdominal pain in the upper right quadrant | Hepatic metastasis |
| 10 | 1. Immediate admission to the ICU<br>2. Using antibiotics | 1. Memory loss<br>2. Confusion and drowsiness | Acute liver failure |
| 11 | 1. Blood test | 1. Jaundice<br>2. Skin rash<br>3. Abdominal swelling | Chronic liver failure |
| 12 | 1. Biliary ultrasound<br>2. CT scan<br>3. MRI<br>4. Chalet Synthesis<br>5. ERCP<br>6. Blood test | 1. Abdominal pain in the right upper quadrant or upper abdomen<br>2. Back pain and shoulder pain<br>3. Natural nausea and vomiting | Gallstones |
| 13 | 1. Blood test<br>2. Radiography<br>3. Sonography<br>4. CT scan<br>5. Biliary hepatic<br>6. Cholangiography | 1. Abdominal pain in the right upper quadrant<br>2. Back pain and shoulder pain<br>3. Fever<br>4. 4- Natural nausea and vomiting | Cholecystitis (gallbladder inflammation) |
| 14 | 1. Blood test<br>2. Abdominal ultrasound<br>3. CAT scan | 1. Pain in the upper abdomen<br>2. Natural nausea and vomiting<br>3. Abdominal swelling<br>4. Fever | Acute pancreatitis |
| 15 | 1. Pancreatic Function Test<br>2. Sonography<br>3. ERCP<br>4. CAT scan | 1. Pain in the upper abdomen<br>2. Natural nausea and vomiting<br>3. Bowel disease in the form of fatty diarrhea<br>4. Weight loss | Chronic pancreatitis |
| 16 | 1. CT scan<br>2. MRI<br>3. PET scan<br>4. Sonography<br>5. Endoscopic<br>6. Laparoscopy<br>7. ERCP<br>8. Liver cholangiography | 1. Jaundice<br>2. Abdominal pain in the upper or central part<br>3. Weight loss<br>4. 4-Anorexia | Pancreatic cancer |
| 17 | 1. Blood test<br>2. Intestinal radiography<br>3. Lower gastrointestinal radiography<br>4. Lower gastrointestinal endoscopy | 1. Pain in the central abdominal area<br>2. Flatulence<br>3. Defective stool discharge<br>4. Symptoms of diarrhea without<br>5. Hemorrhage or constipation without hemorrhage or diarrhea without constipation<br>6. The Sour feeling after eating food in the stomach | Irritable Bowel Syndrome |
| 18 | 1. Blood test<br>2. Sampling of the small intestine<br>3. Endoscopy | 1. Bowel disease in the form of fatty diarrhea<br>2. Bloating<br>3. Weight loss<br>4. Fatigue<br>5. Bone or joint pain | Celiac |
| 19 | 1. Blood test<br>2. Stool test<br>3. Gastric radiography Lower<br>4. Gastrointestinal radiography<br>5. Colonoscopy<br>6. Sampling | 1. Abdominal pain in the central or upper right quadrant or lower right quadrant<br>2. Bowel disease in the form of diarrhea without bleeding or diarrhea with bleeding<br>3. Weight loss<br>4. Bone or joint pain<br>5. 5- Anal bleeding | Crohn |
| 20 | 1. Anal finger examination<br>2. Barium swallowing radiography<br>3. Sigmoidoscopy<br>4. Colonoscopy | 1. Abdominal pain in the central part 2- Bowel movements in the form of bloody diarrhea or constipation<br>2. Anal bleeding<br>3. Weight Loss | Colon polyp |
| 21 | 1. Blood test<br>2. Abdominal radiography<br>3. CT Scan<br>4. Sonography | 1. Fecal nausea and vomiting<br>2. Abdominal pain in the central part<br>3. Constipation in the form of constipation without bleeding | Ileus |
| 22 | 1. Anal finger examination | 1. Abdominal pain in the right lower quadrant of the | Diverticular |

| | | | |
|---|---|---|---|
| | 2. Radiography | left lower quadrant or the lower or central part<br>2. Flatulence<br>3. Constipation without bleeding | |
| 23 | 1. Detailed physical examination of the abdomen<br>2. Blood test<br>3. Urinalysis<br>4. Abdominal radiography<br>5. Abdominal ultrasound<br>6. CT Scan<br>7. Laparoscopy | 1. Abdominal pain in the right lower quadrant or the lower quadrant<br>2. Anorexia<br>3. Natural nausea and vomiting | Appendicitis |
| 24 | 1. Abdominal radiography<br>2. Peritoneal lavage | 1. Abdominal pain in central areas<br>2. Fever<br>3. Abdominal stiffness | Peritonitis |
| 25 | 1. Stool test<br>2. Anal finger examination<br>3. Barium swallowing radiography<br>4. Sigmoidoscopy<br>5. Colonoscopy<br>6. Sampling | 1. Bowel movement naturally and with bleeding<br>2. Stool narrowing<br>3. Weight Loss<br>4. Fatigue<br>5. Natural nausea and vomiting | Colon cancer |
| 26 | 1. Anal finger examination<br>2. Anal viewing with the endoscope<br>3. Colonoscopy | 1. Bowel movement naturally and with bleeding<br>2. Anal pain | Hemorrhoids |
| 27 | 1. Detailed physical view of the anus<br>2. Manometry | 1. Anal pain<br>2. Constipation<br>3. Anal bleeding | Anal fissure |
| 28 | 1. Anal finger examination 2- Endoscopy<br>2. Proctoscopy<br>3. Intracranial ultrasound<br>4. Sampling | 1. Anal bleeding<br>2. Anal pain<br>3. Bumps around the anus<br>4. Feeling itching around the anus | Anal Cancer |

### 3.2.1. Explanation of all the six cancers among gastrointestinal diseases [14]

#### 3.2.1.1 Gastric (stomach) cancer

Gastric (stomach) cancer (Fig. 2) happens when cancer cells form in the inside layer of the stomach. Risk factors include smoking, infection with H. pylori bacteria, and certain congenital circumstances. For the past several decades, rates of cancer in the main part of the stomach (stomach body) have been falling wide-reaching. At the same time, cancer in the part where the top part of the stomach (cardia) encounters the lower end of the swallowing tube (esophagus) has to turn out to be much more common. This part of the stomach is named the gastroesophageal junction.

**Fig 2:** Gastric (stomach) cancer

#### 3.2.1.2 Esophageal cancer

Esophageal cancer (Fig. 3) is cancer that happens in the esophagus — an extended, hollow tube that runs from your throat to your stomach. Your esophagus aids transfer the food you swallow from the back of your throat to your stomach to be absorbed. Esophageal cancer frequently starts in the cells that line the inside of the esophagus. It can happen anyplace lengthways the esophagus. The number of men who get esophageal cancer is more than women. Esophageal cancer is the sixth most public cause of cancer deaths in all over the world. Occurrence rates differ in various parts of the world. In some areas, many esophageal cancer cases might be attributed to tobacco and alcohol consumption or nutritional traditions and obesity.

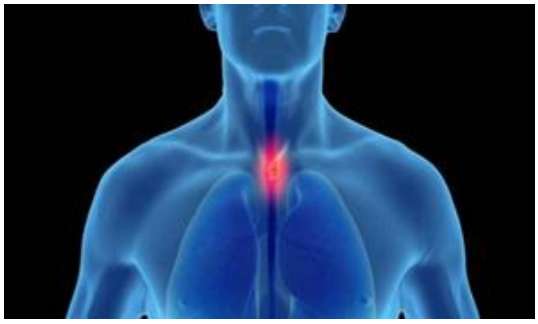

**Fig 3:** Esophageal cancer

#### 3.2.1.3 Liver cancer

Liver cancer (Fig. 4) is cancer that starts in the cells of your liver. Your liver is a football-sized tissue that sits in the upper right part of your abdomen, under your diaphragm and top of your stomach. Numerous kinds of cancer can form in the liver. The most public form of liver cancer is hepatocellular carcinoma, which starts in the key sort of liver cell (hepatocyte). Other categories of liver cancer, such as intrahepatic cholangiocarcinoma and hepatoblastoma, are much less common.

**Fig 4**: Liver cancer

#### 3.2.1.4 Pancreatic cancer

Pancreatic cancer (Fig. 5) starts in the nerves of your pancreas — a tissue in your abdomen that lies behind the lower part of your stomach. Your pancreas produces enzymes that help ingestion and releases hormones that manage your blood sugar. Numerous categories of progressions can happen in the pancreas, consist of cancerous and noncancerous tumors. The most public sort of cancer that happens in the pancreas starts in the cells that line the channels that transfer digestive enzymes out of the pancreas (pancreatic ductal adenocarcinoma). Pancreatic cancer is rarely distinguished at its primary steps when it's most treatable. This is because it frequently doesn't cause signs till after it has spread to another body part.

**Fig 5:** Pancreatic cancer

#### 3.2.1.5 Colon cancer

Colon cancer (Fig.6) is a kind of cancer that starts in the large intestine (colon). The colon is the last portion of the digestive area. Colon cancer characteristically happens to older people, though it can occur at any age. It typically initiates as minor, noncancerous (benign) clumps of cells named polyps that form on the inside of the colon. Over time some of these polyps can turn out to be colon cancers.

**Fig 6:** Colon cancer

#### 3.2.1.6 Anal cancer

Anal cancer (Fig.7) is an infrequent kind of cancer that happens in the anal canal. The anal canal is a short tube at the end of your rectum through which stool leaves your body. Anal cancer can cause indications such as rectal blood loss and anal discomfort. Most people with anal cancer are preserved with a mixture of chemotherapy and radiation. However, merging anal cancer actions rises the chance of treatment, the combined method also raises the danger of side effects.

**Fig 7:** Anal cancer

### 3.3 Using VP-EXPERT shell to diagnose gastrointestinal diseases

#### 3.3.1 Expert System

Expert systems are a branch of artificial intelligence that emerged in the 1980s after two or three decades, and quickly found many applications in a variety of areas. Expert systems have had successful applications in the areas of consulting and decision making in management, business, economics, troubleshooting, and medical diagnosis. An expert system is a smart computer program that uses knowledge and inference methods to solve problems that generally require considerable human expertise. Just as a person comes to his knowledge for decision making and the selection and after a necessary examination and inference, selects and presents a particular case, the expert system also provides guidance and solutions using a knowledge base as well as the necessary review. So, an expert system consists of the following components:

a. Knowledge Base
b. Inference Engine
c. User Interface

It should be noted that in 1898, Maston reports that up to 1,200 GM dealers in the United States have used expert systems for risk analysis. Meanwhile, NASA used an expert system in 1988 to decide on the Discovery space shuttle flight management. The structure of an expert system is illustrated in Fig 8:

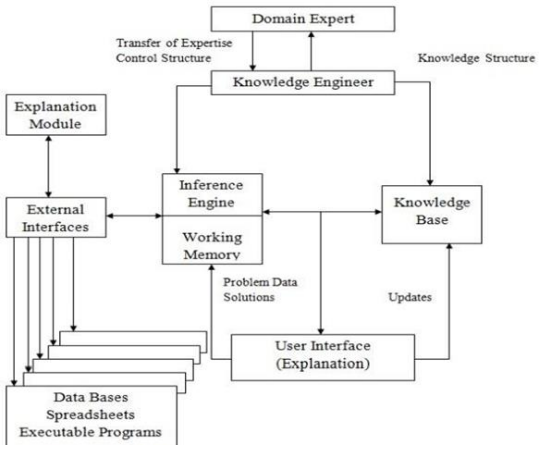


**Fig 8:** The structure of an expert system

### 3.3.2 VP-EXPERT shell

This software was released in 1993 by World Tech Systems in The United States as a tool for developing rule-based expert systems. For the features of this software can be mentioned as follows:

a. Ability to create a knowledge base file with a simple table
b. Ability to create and perform calculations on percentages of confidence (CNF), which can give the user some inaccurate reasoning. However, these properties can only be used in cases that are compatible with the nature of the concepts under consideration, because they are limited to a context and adhere to fixed rules.
c. Chaining capability to link multiple knowledge bases together
d. Automatically generate some questions that cannot be reached without knowing their answers.
e. The existence of relatively diverse mathematical functions
f. Instructions that require the expert system to explain its activities during a consulting task.
g. The threshold level of truth or truth. The VP-EXPERT shell extracts the facts from the system facts set during the CNF argument below the threshold level.

Due to the importance of timely diagnosis of gastrointestinal diseases, this project has attempted to determine the initial diagnosis and major tests necessary for the final diagnosis of gastrointestinal disease with the help of VP-Expert. To this end, it was first attempted to identify the most important diseases of the human gastrointestinal tract through library studies. Then according to the opinions of experts, we determine the most common symptoms of these diseases. Most of the tests needed for a definitive diagnosis of these diseases were also determined through reliable scientific sources. Thus, the VP-Expert Inputs are symptoms of a disease that is known during questions and answers from the patients. In doing so, the VP-Expert Outcome going to be the possible disease, as well as the tests needed to final diagnose the disease. The proposed expert system performs to diagnose gastrointestinal disease problems by asking questions that need Yes/no answers. The proposed expert system will ask the user to select the correct answer on each screen. At the end of the diagnosis meeting, the proposed expert system offers the proper diagnosis of the problem and present a recommendation for the treatment to the users.

## 4. Conclusion

In this paper, we present an expert system for the diagnosis of gastrointestinal disease and determine the type of tests required for the final diagnosis of gastrointestinal disease. First, common gastrointestinal diseases, symptoms, and major tests required for their definitive diagnosis by library studies as well as credible scientific resources were reviewed. After explaining the concept of expert systems with the help of a VP-Expert shell, the expert system was designed. Patients' symptoms were considered as input and diagnosis of gastrointestinal disease as well as the type of tests needed for final diagnosis as VP-Expert output. The results show that the designed system can be useful in cases where there is no immediate access to the expert and in cases where it helps the expert to determine and prescribe the type of tests required. The expansion of fuzzy expert systems with the combination of more cleverness, interdisciplinary and hybrid systems is yet the potential area to see the sights in the medical field in the future and such systems will be called the third-generation expert systems. However, the weakness of the designed system is that the system operates solely on the user's responses and cannot verify the accuracy of the responses received by the user.

**The following is the code written in the VP-EXPERT shell along with some expert system implementation pages**

ENDOFF; ACTIONS CLS COLOR=1
DISPLAY “Hi, Please be calm…” DISPLAY “Please answer below questions.” FIND possible_ disease
DISPLAY “The patient’s possible disease is {possible_disease}” FIND test
DISPLAY “Necessary tests are {test}”; RULE 1
IF body_temperature=above_37_degrees AND Feces=diarrhea_Non_bloody AND Evacuation=No AND Diameter_of_feces=natural AND Urine=natural AND Nausea_and_vomiting=natural_vomiting AND Abdominal_pain=central_pain AND Flatulence_problem=No AND Abdominal_lump=No AND Abdominal_dropsy=No AND Tight_abdomen=No AND Headache=Yes AND
Cough=No AND Swallowing_problem=No AND Regurgitation=No AND Belching_problem=No AND Anorexia=No AND Weight_loss=No AND Extremely_tired=No AND Memory_decrease=No AND Dizzy_and_sleepy=No AND
Bone_pain_or_the_joint_pain=No AND Yellowing=No AND
Body_itchiness=No AND Back_ and _ shoulder _ pain=No AND Bleeding_ from_ the_ rectum=No AND Rectum_ pain=No AND Lump_ around_ the_ rectum=No AND Itchiness_ in_ the_ rectum=No AND Non-liver_ cancer=No
THEN possible_disease=viral_gastroenteritis; RULE 2
IF body_temperature=above_37_degrees AND Feces=diarrhea_Non_bloody AND Evacuation=No AND Diameter_of_feces=natural AND Urine=natural AND Nausea_and_vomiting=natural_vomiting AND Abdominal_pain=central_pain AND Flatulence_problem=No AND Abdominal_lump=No AND Abdominal_dropsy=No AND Tight_abdomen=No AND Headache=No AND
Cough=No AND Swallowing_ problem=No AND Regurgitation=No AND Belching_problem=No AND Anorexia=No AND Weight_loss=No AND Extremely_tired=No AND Memory_decrease=No AND Dizzy_and_sleepy=No AND
Bone_pain_or_the_joint_pain=No AND Yellowing=No AND Body_ itchiness=No AND Back_ and_ shoulder_ pain=No AND Bleeding_ from_ the_ rectum=No AND Rectum_ pain=No AND
Lump_ around_ the_ rectum=No AND Itchiness_ in_ the_ rectum=No AND Non-liver_ cancer=No
THEN possible_ disease=food_ intoxication;
RULE 56
IF possible_ disease=anal_ fissure
THEN test=rectum_ examination_ with_ finger Test=manometry;
RULE 57
IF possible_ disease= nal_ cancer
THEN test=rectum_examination_with_finger

Test=endoscopy
Test=proetoscopy Test=rectum_ sonography Test=biopsy;
ASK body_ temperature:" How much is the patient's body temperature?"; CHOICES body_temperature:37_degrees,above_37_degrees;
ASK feces:" How is the patient's feces?";
CHOICES
feces:completely_ natural, natural_ &_ bloody, natural_&_black,natural_&_pale,diarrhea_&_bloody,diarrhea_Non_blood, fatty_ diarrhea, dry_ &_ bloody, dry_ Non_ bloody;
ASK itchiness_ in_ the_ rectum:" Does the patient have itchiness in the rectum?"; CHOICES itchiness_ in_ the_ rectum: Yes, No;
ASK Non_ liver_ cancer:" Does the patient have a Non.liver cancer background?"; CHOICES Non_ liver_ cancer: Yes, No; PLURAL: test;

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