CHAPTER - 7

DIAGNOSIS OF CARDIAC DISEASES USING DYNAMIC DATABASE AND TURBO PROLOG‡

7.1 Introduction

This chapter presents a method using dynamic database and Turbo Prolog language (discussed in chapter 4) for the diagnosis of electrocardiogram diagnosable diseases. The 'patient data matrix' obtained through the data acqusition programs, the string generation and compression programs, wave recognition and feature extraction programs, the axis analysis program and the heart rate measurement program together with the recent diagnostic criteria of heart diseases have been used for the purpose. The computer program developed in Turbo Prolog can be connected to the programs developed earlier using BASIC language (chapter 6) to provide immediate on-site ECG interpretation.

On checking the patient data matrix with the updated diagnostic criteria,a string of characters consisting of the characters either 'y' or 'n' is generated and saved in a file named 'PAT.DAT'. Of course this file is created using the BASIC language. Later, the Turbo Prolog program, developed for diagnosis of cardiac diseases, fully utilizes this file by the name reply_file. Basically the file "PAT.DAT" and reply_file are same i.e., one is a symbolic file name whereas the other is the file

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‡ This chapter is based on the author's published paper no. 1.

predominant in the ECG waveform cycle. Except for the last disease, the diseases studied here cover four different areas of the ventricles, which represent a large portion of the total ventricular muscle. Also, it is found that left atrial hypertropy is common and right atrial hypertrophy is rare [114]. So only the left atrial hypertrophy is considered.

From the stand point of electrocardiographic diagnosis, it is commonly seen that some diseases can't be diagnosed in presence of others. A closer look on the diseases reveals that left ventricular hypertrophy and left anterior hemiblock cannot be diagnosed in presence of left bundle branch block. Similarly, left ventricular hypertrophy cannot be diagnosed in presence of right bundle branch block. The term 'not diagnosed' means that in the diagnostic report left ventricular hypertrophy and left anterior hemiblock will not be present if already left bundle branch block is present there. So in terms of dependent and independent relation the following can be observed.

i) Disease (3) and (4) are dependent on disease(1).

ii) Disease (3) is dependent on disease (2).

iii) Disease (3) is independent on disease (4) and disease (5).

iv) Disease (4) is independent on disease (2), disease (3) and disease (5).

v) Disease (5) is independent to any other diseases under consideration.

These relations will be utilized in generation and ordering of the production rules of the proposed method.

7.3 Bundle branch block

A bundle branch block is an electrocardiographic term which defines the specific type of electrocardiographic pattern that results from failure of conduction through either the right bundle branch or the main division of the left bundle branch [64]. Conduction through muscle is much slower than through the specialized conducting tissues and hence the QRS complex is wider than normal (i.e. greater than 0.12 sec.) in bundle branch block. When the duration lies between 0.10 and 0.12 sec., either incomplete bundle branch block or some form of intraventricular block is said to be present. When the left branch is blocked, the intrinsicoid deflection over the right ventricle (e.g., in V1 or V2) begins on time, whereas over the left ventrucle (e.g., in V5 or V6) this deflection is much delayed. On the otherhand, when the right branch is blocked, the intrinsicoid deflection is on time in left ventricle but is late over the right ventricle. The QRS complex on right chest leads often becomes M-shaped in right bundle branch block, while wide S waves appear in left leads [64].

Left bundle branch block (LBBB)

Generally the septum is normally activated from the left side first. But in the case of left bundle branch block, the septum is activated from its right side and not the left. Thus there is initially a Q wave in leads facing the right ventricle and an R wave in leads facing the left ventricle. Next, the right ventricle is excited through its undamaged bundle branch and produces on R wave in leads facing the right ventricle and a smaller S wave in the more distant leads facing the left

ventricle. Before this can develop fully the left ventricle is excited and causes an S wave in leads facing the right ventricle and an R' in those facing the left ventricle.

Right bundle branch block (RBBB)

The septum is excited normally, giving an R wave in leads facing the right ventricle and a small Q wave in leads facing the left ventricle. Excitation of the left ventricle produces an S wave in leads facing the right ventricle and an R wave in those facing the left ventricle. Excitation of the right ventricle now gives an R' wave in leads facing the right ventricle and an S wave in those facing the left ventricle. The T wave usually points in a direction opposite to the major deflection of the QRS. In the limb leads, the major deflection of the QRS is usually upright in lead I and downward in lead III, in left bundle branch block. In right bundle brach block there is usually a deep wide S in lead I and tall wide R' in lead III. The feature of left and right bundle branch blocks are demonstrated in Fig. 7.1.

Left and right bundle branch blocks occur with about the same frequency [7,9]. Coronary diseases is much the commonest cause of persistent bundle branch blocks. Other causes are rheumatic disease, trauma, cardiomyopathy etc. Both right and left branch block are occasionally seen in apparently normal hearts. Transient bundle branch block may occur in acute heart failure, acute myocarial infarction, acute coronary insufficiency and acute infection, or may rarely result from digitalis of quinidine intoxication.

7.4 Left ventricular hypertrophy (LVH)

Left ventricular hypertrophy results from any pathological process which produces a sufficient load on left ventricle. If the wall of the left ventricle is thicker than normal, the impulse will take longer to traverse it.Therefore, the QRS interval will increase towards or to the upper limit of normal. It commonly results from the following clinical states [114].

1. Hypertension (essential, renal, or hormonal).
2. Aortic valvular disease (aortic stenosis or aortic insufficiency (or both)).
3. Mitral insufficiency due to various causes.
4. Longstanding coronary artery diseases.
5. Nutritional and idiopathic hypertrophies (beriberi heart disease and the chronic myocarditides and myocardiopathies).
6. Congenital heart disease.

Increased voltage of QRS complex always indicates the left ventricular hypertrophy disease. Increased voltage of QRS is usually best seen in the chest leads. Thus, leads oriented to the left ventricle-usually leads V5 and V6, standard lead I and lead aVL will record tall R waves, and leads oriented to the right ventricle-V1 and V2- will record deep S waves.

In general terms, the total voltage of (SV1 + RV5) or (SV1 + RV6) is greater than 35 mm. or a R wave of amplitude over 27 mm. in V5 or V6 is indicative of left ventricular hypertrophy. This is only applicable to adults over age 30 years. Fig. 7.2 indicates the different electrocardiographic pattern for the left ventricular hypertrophy disease.

Furthermore fever, thyrotoxicosis or other high output states can increase this voltage without representing left ventricular hypertrophy [64].

7.5 Left anterior hemiblock (LAH)

Hemiblock is caused due to the blockage of one of the two main divisions of the left bundle branch. The anterior division runs towards the base of the anterior papillary muscle of the left ventricle, the posterior division towards to posterior papillary muscle. It may be noted that anatomists have called anterior as superior and posterior as inferior. Activation of the left ventricle normally spreads simultaneously from these two locations. If the path to one of these is blocked, activation must begin exclusively from the other location ; thus, if the anterior division is blocked, spread will begin at the base of the posterior papillary muscle and this will shift the general direction of spread upwards, from posterior to anterior.

The posterior papillary muscle is situated not only below but also medial to the anterior muscle. For this reason, the first activation is not only downwards but also somewhat rightward, and this initial spread will give a small Q in lead I with a small R in lead III, the remaining forces travel upwards and to the left to give a R in lead I and a S in lead III and so produces left axis deviation.

Although the left anterior hemiblock represents a form of intraventricular block, this does not lead to material widening of the QRS because the Purkinje network in the territories of

anterior and posterior divisions are richly confluent. So that, althogh the order and direction of activation are drammatically changed, the time required for the depolarization of the entire ventricle is rarely increased by 0.01-0.02 sec. at most. Features of left anterior hemiblock are shown in Fig. 7.3

The left anterior hemiblock has claim to some importance : first, it is the most common cause of otherwise unexplained left axis deviation and, as such, fills a hitherto considerable gap in electrocardiographic knowledge. Second, it can play the alternate roles of mime and mask. It can mimic anterior infarction by producing Q waves in anterior chest leads (especially if the electrodes are placed somewhat above the conventional level); lateral infarction by producing or enhancing Q waves in leads I and aVL and left ventricular hypertrophy by increasing R wave votage in leads I and aVL. This is shown in Fig. 7.4. Left anterior hemiblock can mask inferior infarction by substituting a R wave for a Q in leads II,III and aVF. It can mask anteroseptal infarction (especially if the electrodes are placed somewhat below the conventional level) by converting a QS complex in anterior leads to a rs pattern and left ventricular hypertrophy by diminishing R wave voltage in left chest leads.

Left anterior hemiblock, is commonly caused by ischamic heart disease and was found in 17 percent of 250 consecutive patterns with acute myocardial infarction [65]. Other causes include cardiomyopathy, Lev's disease and aortic valve calcification.

7.6 Left atrial hypertrophy (LAH1)

Atrial hypertrophy may arise under the following pathological conditions (in order of incidence) [114] :

1. Left atrial hypertrophy associated with mitral stenosis.
2. Right atrial hypertrophy resluting from chronic diffuse pulmonary disease.
3. In association with various congenital heart lesions, e.g., right atrial hypertrophy associated with an interatrial septal defect.
4. Left atrial hypertrophy associated with left ventricular hypertrophy,

From the stand point of electrocardiographic diagnosis, atrial hypertrophy can frequently be diagnosed in mitral stenosis, chronic pulmonary disease producing pulmonary hypertension, and certain congenital lesions. It is less commonly diagnosed when associated with left ventricular hypertrophy.

The normal P wave is not over 0.11 sec. in width and 2.5 mm. in height. Any increase in these values is suggestive of atrial hypertrophy. Left atrial hypertrophy is manifested by broad, notched P waves usually best seen in leads I, II and aVL. It produces enlargement and prolongation of the second part of the P wave. Since the left atrium lies to the left and behind the right atrium, a 'P-mitrale' is usually best seen in lead I and in left chest leads. Besides that P wave amplitude more than 3.0 mm. in lead I, II or aVL may suggest left atrial hypertrophy. Fig. 7.5 illustrates the left atrial hypertrophy pattern.

7.7 Diagnostic criteria

The diagnostic criteria for the five diseases are given below. Those are taken from the updated diagnostic criteria published by American Heart Association [28] and from a review of the medical literature [64,103,106,114].

Diagnostic criteria for the five diseases

Criteria labled (A),(B),..,must all be satisfied. In the case of numbered criteria ((1),(2),..), any one or more must be satisfied.

Right-bundle branch block (RBBB):

Left-venticular hypertrophy cannot be diagnosed in the presence of RBBB.

(A1) Amplitude of R wave (A_R),amplitude of S wave (A_S) and amplitude of R' wave each complex is greater than 6mm in lead V1 or V2.Also the width of R'($D_{R'}$) is greater than 0.025s in lead V1 or V2.

(A2) Ventricular activation time (T_{VA}) is greater than 0.04s in V1 or V2.

(B) Duration of S wave (D_S) in lead I is greater than or equal to 0.03s.

(C) QRS duration (T_{QRS}) is greater than 0.12s.

Left-bundle branch block (LBBB):

Left-ventricular hypertrophy and left-anterior hemiblock cannot be diagnosed in the presence of LBBB.

(A) QRS duration (T_{QRS}) is greater than 0.12s.

(B) A_R, A_S and $A_{R'}$, each complex is greater than 6mm in at least one of the leads I, aVL,V5 and V6, or notched R wave (i.e. the duration of R wave is greater than 0.04s) present in at least one of the leads I,aVL,V5 or V6.

Left-ventricular hypertrophy (LVH):

(A1) A_R is greater than 27mm in lead V5 or V6.

(A2) Q wave amplitude (A_Q) or A_S in lead V1 plus A_R in lead V5 or V6 is greater than or equal to 35mm.

(A3) A_R is greater than or equal to 13mm in lead aVL.

(A4) A_R in lead I plus A_S in lead III is greater than or equal to 26mm.

(B) Patient's age is above 30 years.

Left-anterior hemiblock(LAH):

(A) Left-axis deviation(LAD) is between -45^0 and -60^0.

(B) Q wave duration is less than or equal to 0.02s in lead I and aVL.

(C) A_R is less than 5mm in leads I,II,III and aVF.

(D) Normal QRS duration (pure LAH can increase the QRS duration no more than 0.02s, thus a QRS duration of 0.11s indicates the coexistence of RBBB or some other form of ventricular conduction abnormality).

Left-atrial hypertrophy(LAH1):

(A1) Notched P wave amplitude (A_P) and P' wave amplitude ($A_{P'}$) is greater than 1mm. in leads I,II or aVL.

(A2) A_p is greater than 3mm in lead I or in lead aVL, or equal to 3.5mm in lead II.

(B) Overall P wave duration (D_p) is greater than 0.11s.

7.8 The reply_file/PAT.DAT

A series of questions will be asked by the software of the proposed method in the consultation session. The answers may be provided from the console directly or from an internal file containing the answers by means of the characters 'y' or 'n' indicating 'true' or false'. In the present work that internal file is nothing but the reply_file/'PAT.DAT'. As mentioned earlier, the files 'PAT.DAT' and reply_file represent same file.

The 'patient data matrix' is checked against each diagnostic criterion in the order as given in section 7.7, and the outcome ('y' or 'n') is transfered into the file reply_file / PAT.DAT sequentially depending on the condition (true or false) of each criterion. In general, there is no fashination in the ordering of diagnostic criteria as the reply_file contains only the information regarding satisfication/disatisfication of each criterion.

An algorithm for the generation of the reply_file / 'PAT.DAT' is given below.

Algorithm REPLY

Input : Patient data matrix / PDM.DAT file.

Output :reply_file/PAT.DAT file : contains i symbols from the character set {n,y}, i being the total number of diagnostic criteria.

Step 1 :Open the file PAT.DAT, and set i = 1

Step 2 :If the criterion i is satisfied (by checking PDM.DAT) then transfer the character 'y' to the i-th position of the file PAT.DAT, and go to step 4.

Step 3 :Transfer the character 'n' to the i-th position of the file PAT.DAT.

Step 4 :Set i = i + 1.

Step 5 :If i is greater than the total number of diagnostic criteria under consideration then continue, otherwise go to step 2.

Step 6 :Close the file PAT.DAT.

Step 7 :Exit.

Example 7.1

It is assumed here that the following partial information were obtained from the patient data matrix for a particular ECG wave. Other measurement parameters are ignored for ease of understanding. The information are :

1. RA is less than 6mm. in lead V2.
2. VAT is less than 0.04 sec. in lead V1.
3. SD in lead I is greater than 0.03 sec.
4. Overall QRS duration is greater than 0.12 sec.

The first four positions of the file PAT.DAT will contain the characters n,n,y,y respectively.

7.9 The knowledge base

As discussed in the section 4.5, the knowledge base in the data or knowledge used to make decisions are usually refers to

rules and facts of the problem. The Prolog static database is the rule base whereas working memory is treated as dynamic database. Much of the medical knowledge are contained in the rule base. The dynamic database is created in each consultation using the Turbo Prolog built-in database predicates. In the proposed method, the knowledge base is the dynamic database which stores the information about the diagnostic criteria as well as the possible presence of heart diseases. Since some of the selected heart diseases depends on the presence of the other heart disease, the storing of each and every disease which are present in the ECG is essential in the dynamic database. The repeatation of the same question can also be avoided using dynamic database in each consultation paradigm.

7.10 Ordering of rules

The Turbo Prolog scans the rules using backward chaining i.e., it starts at the goal and works backward in an attempt to prove that the goal is true. The order in which rules for a goal are tried will affect the order in which subgoals are generated. The efficiency of the search thus is affected by the ordering of rules. Again, since the different chosen diseases are inter-related, the ordering of the rules related to diseases are also to be considered intelligently. So the hand-ordering of the rules will affect the construction and traversal of the search space. The most likely rules are to be tried first to save search effort in the majority cases. Knowledge about which rules to try first and the best order for considering conjuncts is a meta-knowledge and is the most crucial aspect of expertise.

In the proposed method, the deseases have been arranged in the following order to generate the rules for diagnosis :

1. Right bundle branch block (RBBB).
2. Left bundle branch block (LBBB).
3. Left atrial hypertrophy (LAH1).
4. Left ventricular hypertrophy (LVH).
5. Left anterior hemiblock (LAH).

7.11 Inexact reasoning [174]

Uncertainity is most often represented in terms of probability. Theories of reasoning that are consistent with the axioms of probability theory are called normative. Human reasoning under uncertainity is clearly not normative, even expert reasoning violates results from probability theory.

The certainity inference approach is probably the most popular in AI, and is what commonly thought of as reasoning under uncertainity. The purpose of these inferences is to tell one how much to believe or disbelieve the conlusions with which they are associated. This does not preclude symbolic reasoning about one's reasons for believing and disbelieving.

The goal in certainity inference systems is to determine which states of the world are most likely to hold. Systems such as EMYCIN associate certainity factors with the conclusions of inference rules. A rule of the form "IF A and B and C, THEN D" asserts D when A,B and C are certain, additionally, a number may be associated with D to indicate one's belief that D follows from A ,B, and C. It may be that A,B and C, though certain, suggest but do not confirm D, in which case the number associated with D might be

less than the 1.0 that usually represents certainity in such systems. If A,B, or C are uncertain, then the number associated with D is modified to account for the uncertainity of its premises. These numbers are also known as degrees of belief. The premise of a rule can be thought of as evidence for (or against) the conclusion of the rule, and the degree of belief associated with the rule can be thought of in terms of the conditional probability of the conclusion given the evidence.

Numerical degrees of belief in current AI Systems are of two kinds :

a) those specified initially as qualifications of domain inference rules and

b) those that are derived from the initial numbers as the system reasons.

Initial numbers are usually supplied by the domain experts. The number is presumably a summery of the reasons for beleiving and disbelieving the inference. Once summarized and associated with the inference rule, however, these reasons are inaccessible, at least to a computer program that uses the rules and degrees of belief.

The second kind of numerical degrees of belief are those derived as an AI system reasons. Two general operations are

i) updating the degree of belief in a hypothesis to reflect some new evidence and

ii) updating the degree of belief of a conclusion to reflect uncertainity about its premises.

One often finds several pieces of evidence for and against a hypothesis, and one wants to compute a net strength of

belief in the hypothesis given all the evidence. Bayes' theorem was used to calculate the conditional probability of a hypothesis given a body of evidence. The technique which uses Bayes' theorem to combine evidence in rule-based inference systems depends on using the initial degrees of belief associated with inference rules to calculate the initial conditional probabilities that Bayes' theorem requires.

In our approach, it is assumed that for each rule of the form "IF A and B and C, THEN D" all A,B and C are uncertain. The degrees of belief of A,B, and C will be supplied on line by the expert for each patient. Associated with each rule, there is a degree of belief supplied by the domain expert (Cardiologist). This number is combined with the degrees of belief of the rule's premises to produce a derived degree of belief in the conclusion. A suggested conclusion is confirmed when its associated degree of belief exceeds a certainity limit fixed by the domain expert. The degrees of belief of the premises are flexible in a sense that these numbers may be varied from patient to patient depending on the domain expert's (Cardiologist's) experience. A typical example in this respect is given in example 7.4.

7.12 The program

The diagnostic program in Turbo Prolog language is given in the 'listing of the programs' section of Appendix.

A dynamic database is used to store the knowledge entered as part of the consultation session using the reply_file and the diseases identified so far. Three database predicates are defined : pos_criteria stores the symptom (criterion) proven true,

neg_criteria stores the symptom (criterion) proven false and pos_disease stores the identified diseases. For example, if the QRS duration is greater than 0.12 sec. in the patient data matrix, then this fact is stored in the database as pos_criteria ("QRS(All)"), otherwise it will be stored as neg_criteria ("QRS(All)"). The knowledge is put to the database using the built in predicate asserta. The hypothesis predicate attempts to verify the disease positively. Each hypothesis rule is of the form :-

```
hypothesis (X) :-
                    not (pos_disease (X1)),
                    not (pos_desease (X2)),
                          :
                          :
                    Cf_rule = n1,
                    symptom (X3,F1),
                    symptom (X4,F2),
                          :
                          :
                    check_min(F1,F2,.....Fn,F12...n),
                    n2 < Cf_rule * F12...n,
                    asserta (pos_desease (X)).
```

The presence of certain diseases are checked first in the knowledge base in order to prove the hypothesis predicate true. If the check succeeds then either the disease being tested for is already present in the database or it may not be diagnosed in the presence of those particular diseases. Cf_rule is the certainity factor (CF) of the rule. The symptom predicates check for symptoms. It also reads the certainity factor imposed to the symptom by the domain expert. The check_min predicate finds the minimum CF value of the symptoms. n2 is the certainity limit of

the head or conclusion of the rule. The conclusion succeeds if all of its premises are true and CF of the conclusion exceeds the value of the certainity limit assigned to it. If the disease can be identified positively, the program puts the disease to the database and then backtracks to identify other diseases. On the contrary, if the program cannot identify any disease at all, it displays "The patient has no disease".

Now examine the symptom predicate, which is perhaps the most complex part of the program. When symptom ("QRS(All)") is invoked, this unifies with

```
symptom ("QRS(All)",F3) :-
        check_indication ("QRS(All)",3),
        criteria_3 (F3).
```

and when check_indication ("QRS(All)",3) is invoked, this unifies first with

```
check_indication (Indication,_) :-
        pos_criteria (Indication,), !.
```

binding Indication to "QRS(All)". If this criteria is not checked before, pos_criteria ("QRS(All)" will not be in the database. The premise will fail, and Prolog will backtrack to

```
check_indication (Indication,_ ) :-
        neg_criteria (Indication), !, fail.
```

binding Indication to "QRS(All)" again. The first premise will fail again, and Prolog will backtrack and eventually begin to test wheather 'y' or 'n' is written in the reply_file at the position 3. (reply_file contains 0 to 17th position i.e., total 18 positions corresponding to 18 considered diagnostic criteria given in section 7.7 and each position contains either the character 'y'

or 'n' depending on the satisfaction or disatisfaction of the diagnostic criterion.) This is done by the following check_indication rules.

```
check_indication (Indication, Position ) :-
        not (neg_criteria (Indication)),
        filepos (reply_file, Position,0),
        readdevice (reply_file),
        readchar (Readdata),
        Readdata = 'y',
        asserta (pos_criteria (Indication)).
```

and

```
check_indication (Indication,_ ) :-
        not (neg_criteria (Indication)),
        asserta (neg_criteria (Indication)),
        fail.
```

The criteria will be stored in one of the two databases (pos_criteria and neg_criteria) depending upon the presence of the character 'y' or 'n' at the required position. The predicate criteria_3 (F3) assigns a value to the variable F3 as the certainity factor of the symptom and displays the criterion. This value must be supplied by the domain expert. At the end of the run, the clear_facts predicate clears the database for the session.

Example 7.2

Let us consider the following hypothesis rule of the Turbo Prolog diagnostic program :

```
hypothesis ("Left-atrial hypertrophy (LAH1)") :-
                    not (pos_desease ("LAH1")),
                    Cf_LAH1_rule1 = 0.8,
                    symptom ("PAP"("AVI/II/aVL)",F15),
                    symptom ("PDC Average"),F17),
                    check_min(F15,F17,F1517),
                    0.6 < cf_LAH1_rule1 * F1517,
                    asserta (pos_disease("LAH1").
```

Here one rule related to the disease left atrial hypertrophy is seen. The certainity factor of the rule is provided by means of the variable Cf_LAH1_rule1. The premise not(pos_disease("LAH1")) checks the presence of left atrial hypertrophy in the database. If it is there, i.e., the check succeeds, the rule fails and prolog backtracks to other rules in order to prove the hypothesis predicate true. On the otherhand if the premise is true , then the symptoms for the LAH1 are tested and if these succeeds then the certainity factor of the conclusion is calculated and compared with the preassigned certainity limit of the rule. The check_min (F15,F17,F1517) prdicate determines the minimum of the CFs F15 and F17 of the two symptoms as shown. The disease LAH1 is stored in the database pos_disease if the CF of the conclusion of the rule exceeds the certainity limit fixed for that rule.

Again, if any of the premises fails the hypothesis rule fails and Prolog backtracks.

Example 7.3

Let us consider the following rule for the disease left

anterior hemiblock (LAH).

```
hypothesis("Left-anterior hemiblock(LAH") ;-
        not(pos_disease("LBBB")),
        not(pos_disease("LAH")),
        Cf_LAH_rule1 = 0.8,
           ..........
           ..........
```

Since left anterior hemiblock cannot be diagnosed in presence of left bundle branch block, it is essential to identify and check the disease left bundle branch block before going to prove hypothesis("Left_anterior hemiblock (LAH)"). This checking has been done by the premise not(pos_disease("LBBB"). The second premise is given for checking wheather the disease LAH has already been identified or not.

Example 7.4

Let the content of the reply_file (pat.dat) for a patient contains the following string :

yynyyynynnyyyyynyy

The output of the diagnostic program is shown below. In order to prove the hypothesis predicate true, the symptoms which are proved true are printed. At the end, a list of possible diseases are displayed by searching the database.

```
MEDICAL    DIAGNOSTIC    SYSTEM    FOR    HEART DISEASES


Ampl. of R wave ,S wave and R' wave each complex is greater
than 6 mm. in lead V1 or V2 and also the width of R' is
greater than 0.025 sec. in lead V1 or V2 with certainity factor =
with certainity factor = 0.8
```

Ventricular activation time is greater than 0.04 sec.
with certainity factor = 0.7

QRS duration is greater than 0.12 sec.
with certainity factor = 0.6

Ampl. of R, S, and R' is greater than 6 mm. in at least one of the leads I, aVL, V5 and V6 or notched R wave is present in at least one of the leads I, aVL, V5 or V6 with certainiti factor = 0.6

Ampl. of P wave is greater than 3 mm. in lead I or in lead aVL or equal to 3.5 mm. in lead II with certainity factor = 0.9

Overall P wave duration is greater than 0.11 sec.
with certainity factor = 0.8

Presence of Left Bundle Branch Block.

Presence of Left Atrial Hypertrophy.

Good-Bye !

7.13 Concluding remarks

In this chapter, a method to analyse the ECG diagnosable diseases is presented. The scheme relies upon the 'patient data matrix' and the different diagnostic criteria of the heart diseases. The method is somewhat similar to the production system, a type of expert system, given in section 4.5 and uses a dynamic database. The program has been written in Turbo Prolog language.

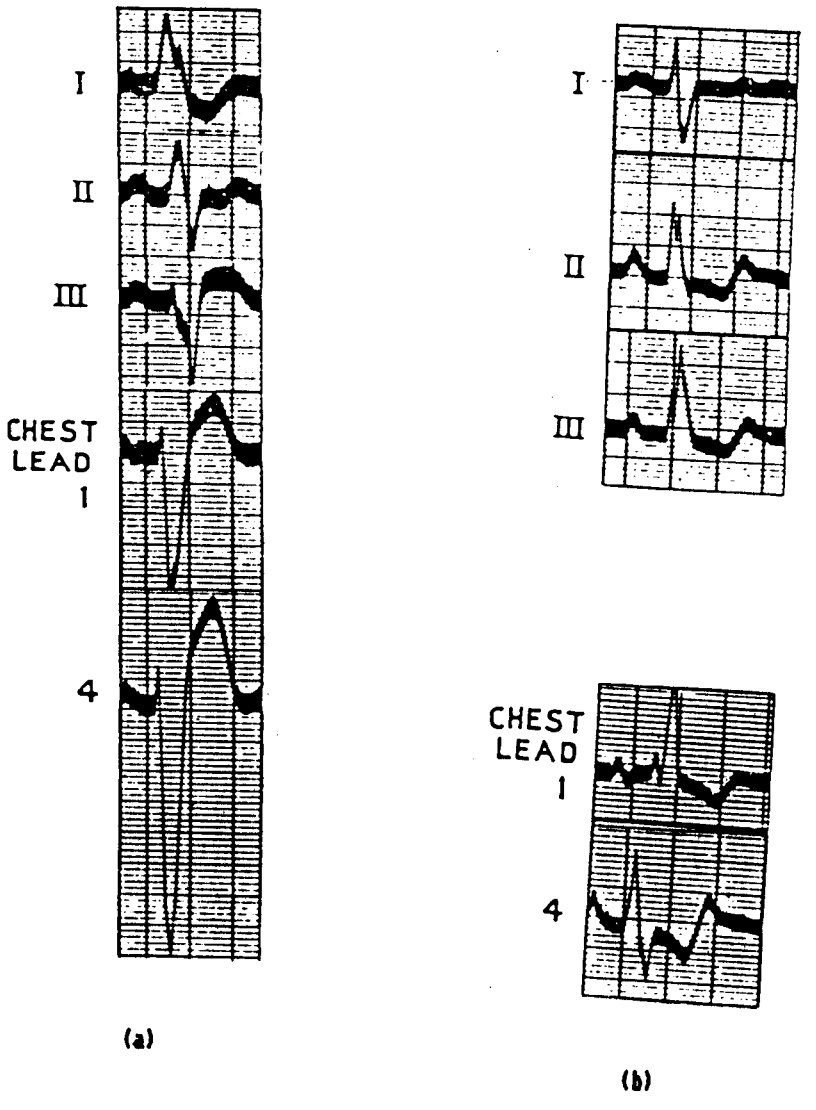

Fig. 7.1 Bundle branch block. a) Left bundle branch block. b) Right bundle branch block.

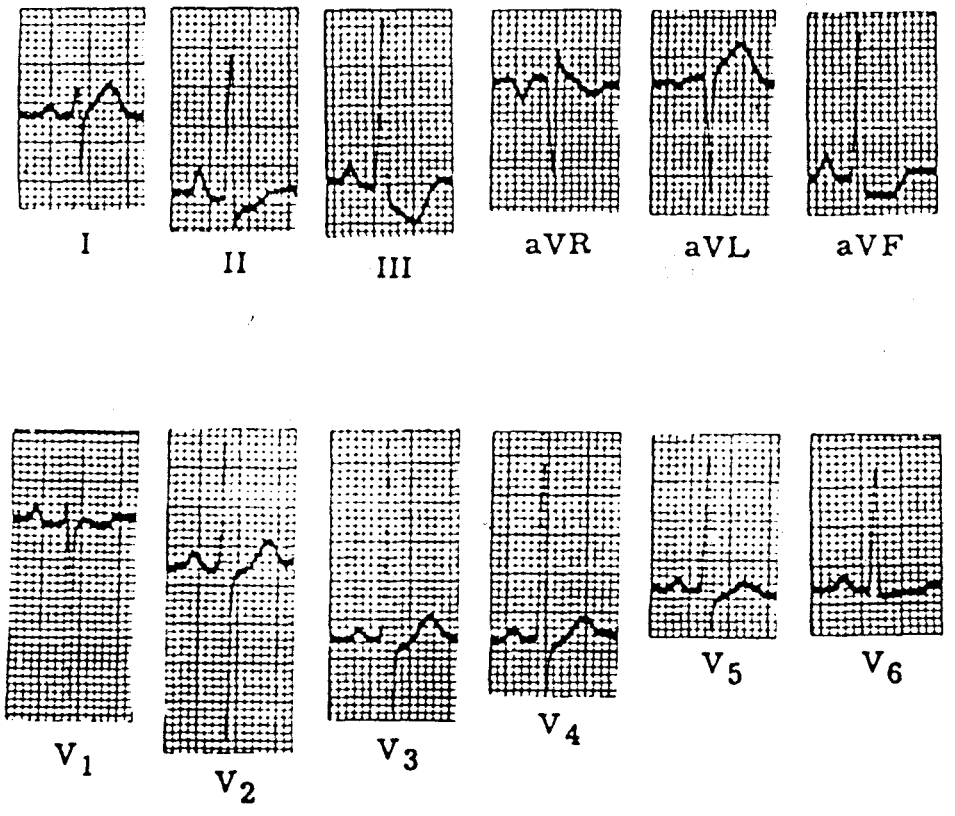

Fig. 7.2 Combined right and left ventricular hypertrophy. The mean frontal plane axis is +105 degree; there is ST depression in leads II, III, aVF, and V5-V6; the T is flat in II and V6; inverted in III and aVF, SV1 + RV5 = 39 mm.

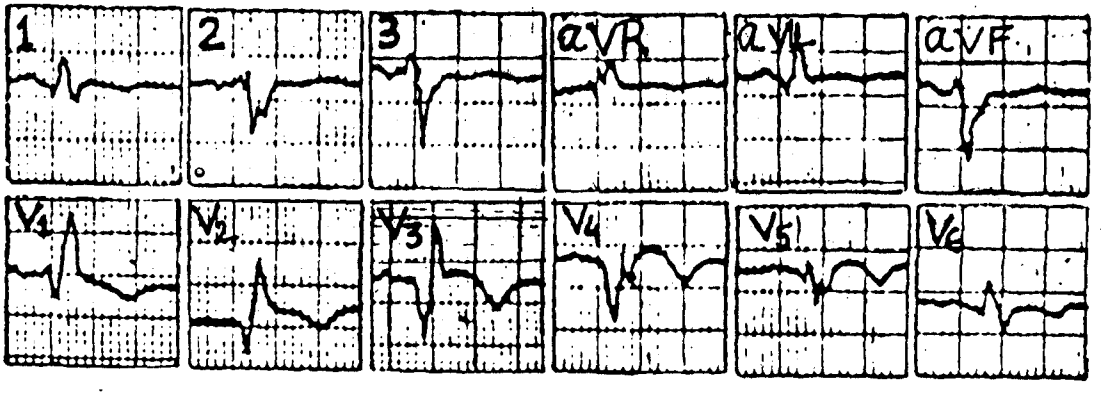

Fig. 7.3 Right bundle branch block + left anterior hemiblock against a background of extensive anterior infarction. In this case the QRS complex are of course abnormally wide because of the RBBB, not because of the hemiblock itself.

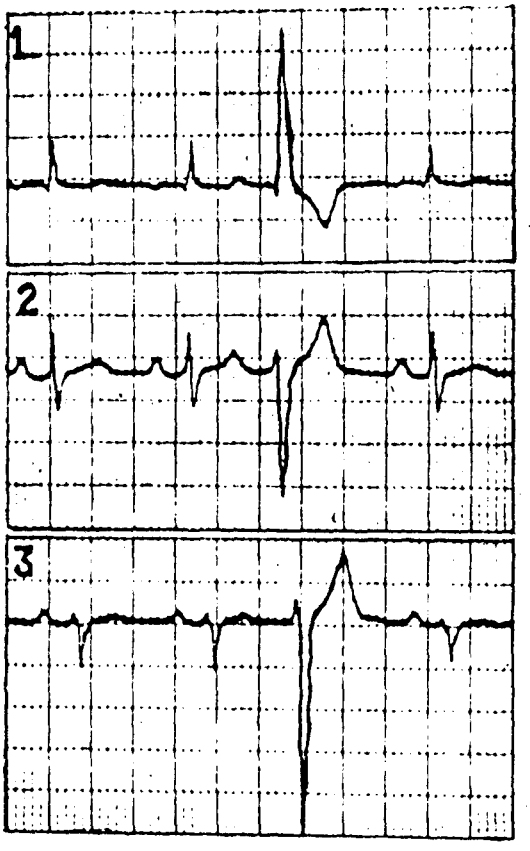

Fig. 7.4 Atrial premature beats with ventricular aberration of left anterior hemibleck type. In the aberrant beats, at the same time that the axis shifts markedly leftwords to about -70°, the voltage of the QRS complex greatly increases so that their pattern simulates that of left ventriculair hypertrophy.

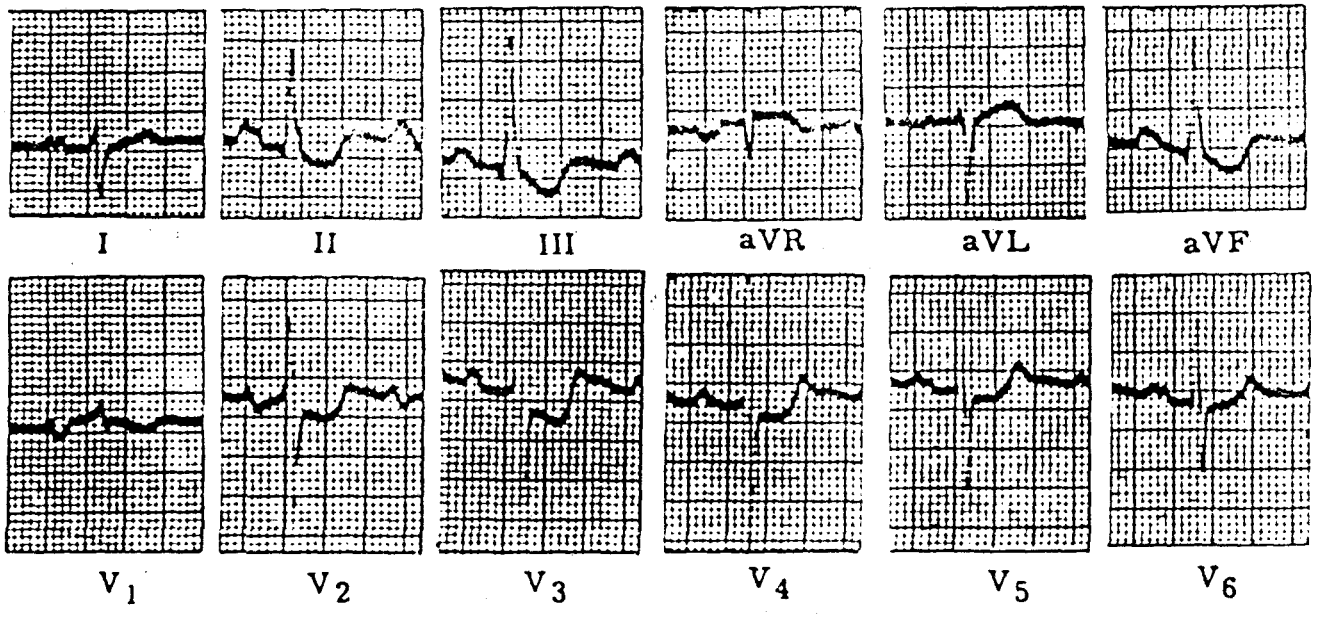

Fig. 7.5 Regular sinus rhythm; P-R = 0.24 sec.; QRS = 0.08 sec.; mean frontal plane QRS axis = +100 degrees; notched P waves of the P mitrale type in leads I and II. There is ST depression with some T wave inversion in leads II and III. The heart position is vertical. There is ST depression and T wave inversion in aVF. A diphasic P with wide negative deflection is seen in V1. A prominent r is present in V1 and a deep S is present in V6. There is ST depression in the precordial leads, most marked in V2-V3.

Interpretation : Right ventricular hypertrophy; Left atrial hypertrophy; first degree AV block; some of the ST-T changes could be the result of digitalis.