RESULTS

THE RESULTS
THE PATIENTS AND THE SYSTEM
THE PATIENTS

Three hundreds patients complaining of low back pain were throughly examined. ESR and X-ray - anteroposterior, lateral, and oblique views - were done for all.

Fifty patients were selected, (33 males and 17 females), as a patient sample, in order to test the system, (Table 24) .

Table 24: Low back pain categories and number of patients in each, in the example patients.

Category	Number of cases
Degenerative	4
Nerve root compression	5
Spondylolisthesis	5
Infective	6
Inflammatory	1
Traumatic	8
Metabolic	4
Neoplastic	4
Spinal stenosis	2
Postural	2
Postlaminectomy	1
Meralgia paraesthetica	1
Senile kyphosis	1
Psychogenic	1
Sacroiliac joint affections	5
Total	**50**

Examiner : A B C
Case No. : 7
Diagnosis :

History: Age : 40 Male

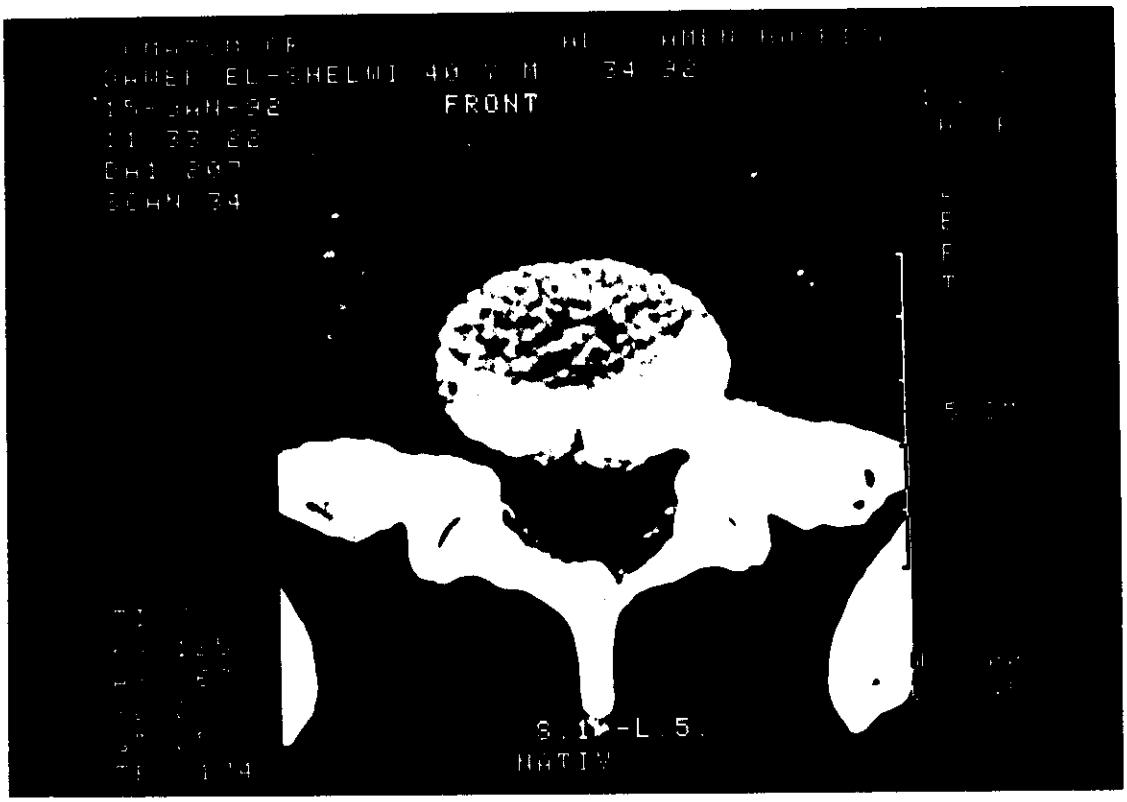
Complaint : Chronic low back pain, pain extends to the left buttock, and back of the thigh. Past history of long treatment, physiotherapy, acute attacks, he is physically active worker.

Examination :

Spasm : Paravertebral muscle spasm.
Tenderness : At L5/S1 junction, gluteal region.
Range of Motion : Limitation of forward flexion.
Motor Power :
Sensation : Hyperaesthesia over the left gluteal region and back of the left thigh.
Reflexes : Loss of ankle reflex.
SLR : + ve, left, limitation and pain.
Pulse :

ESR : Normal.
Ca :
Phosphate :
SAP :
Others :

X-Ray : Normal.
CT : Left posterolateral disc prolapse at level L5/S1, with compression of S1 nerve root.



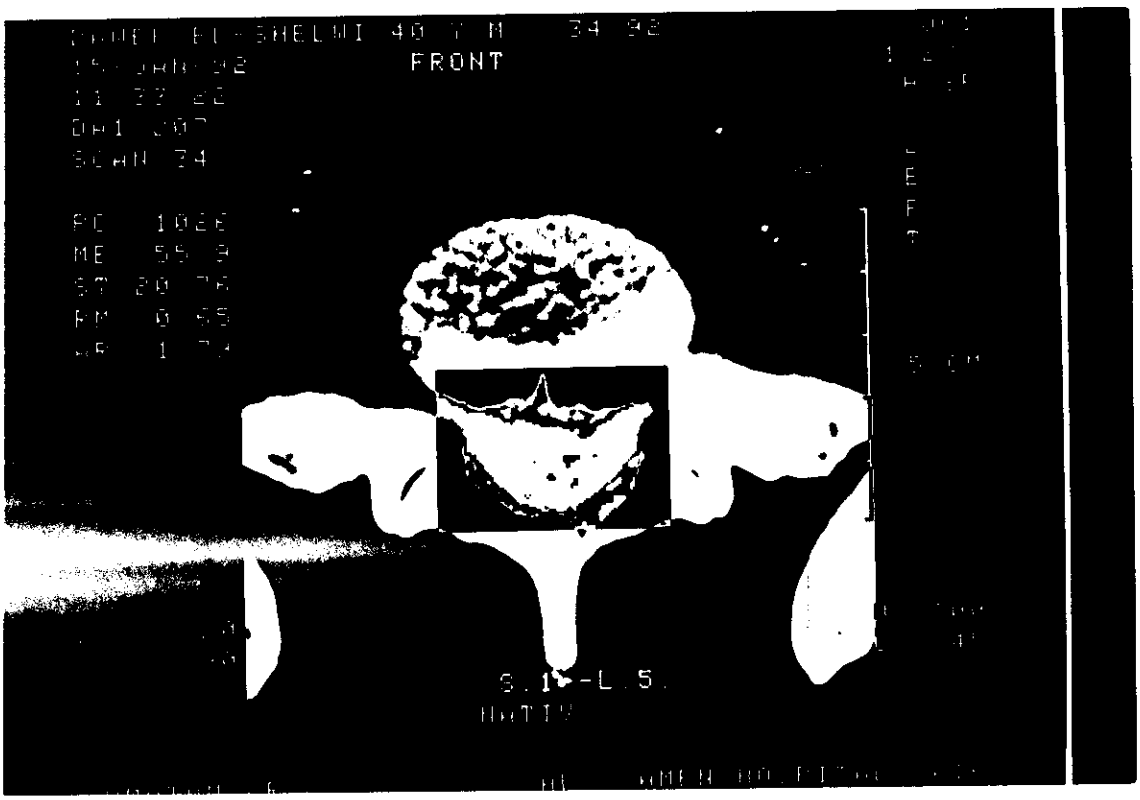
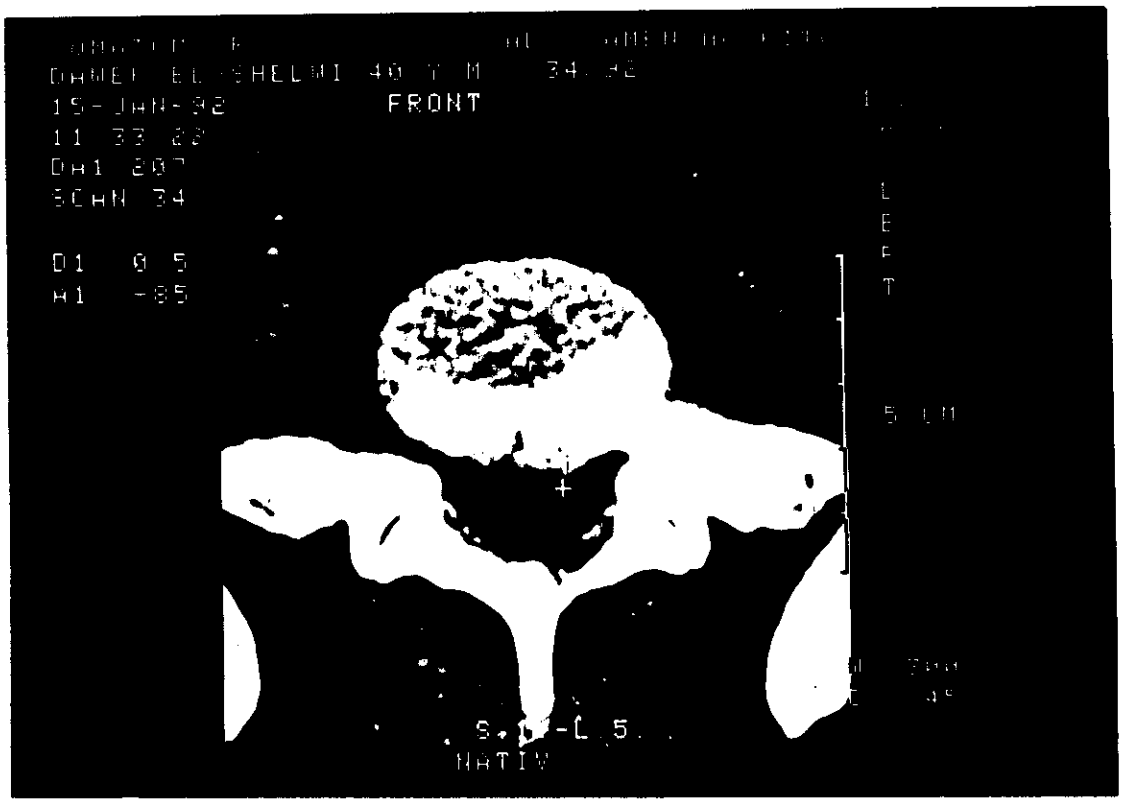


Figure 21



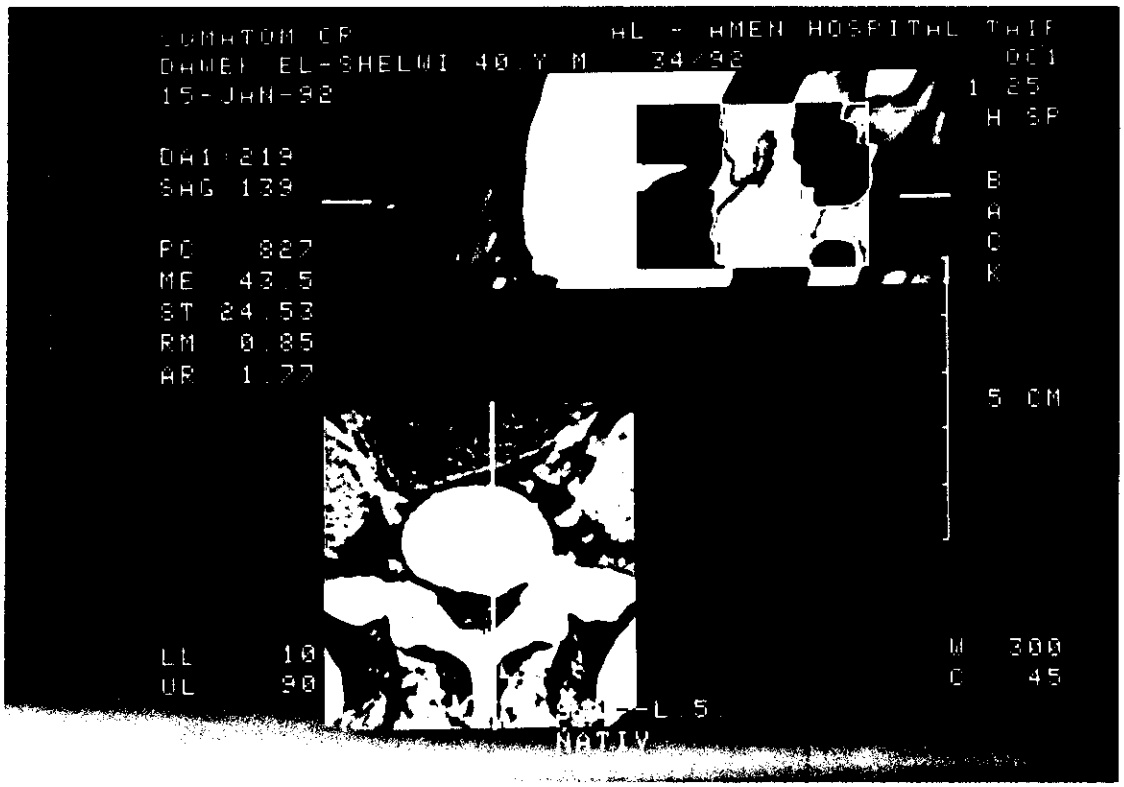


Figure 21 (continued): CT scaning of case No.7 show left dorsolateral disc prolapse level L5S1, with compression of S1 nerve root, left.

Examiner : A B C
Case No. : 33
Diagnosis :

History: Age : 66 Female

Complaint : Chronic low back pain, of gradual onset, long duration, localised of mild severity, no radiation symptoms.

Examination :

Spasm : Paravertebral muscle weakness.
Tenderness : At L4/L5 spines.
Range of Motion : Limitation of forward flexion, and extension.
Motor Power :
Sensation :
Reflexes :
SLR :
Pulse :

ESR : Normal.
Ca : Normal
Phosphate : Normal
SAP : Normal
Others : Normal

X-Ray : Reduced bone density, generalised osteoporosis, calification of the aortic arch, slight narrowing of the posterior aspect of L5/S1.

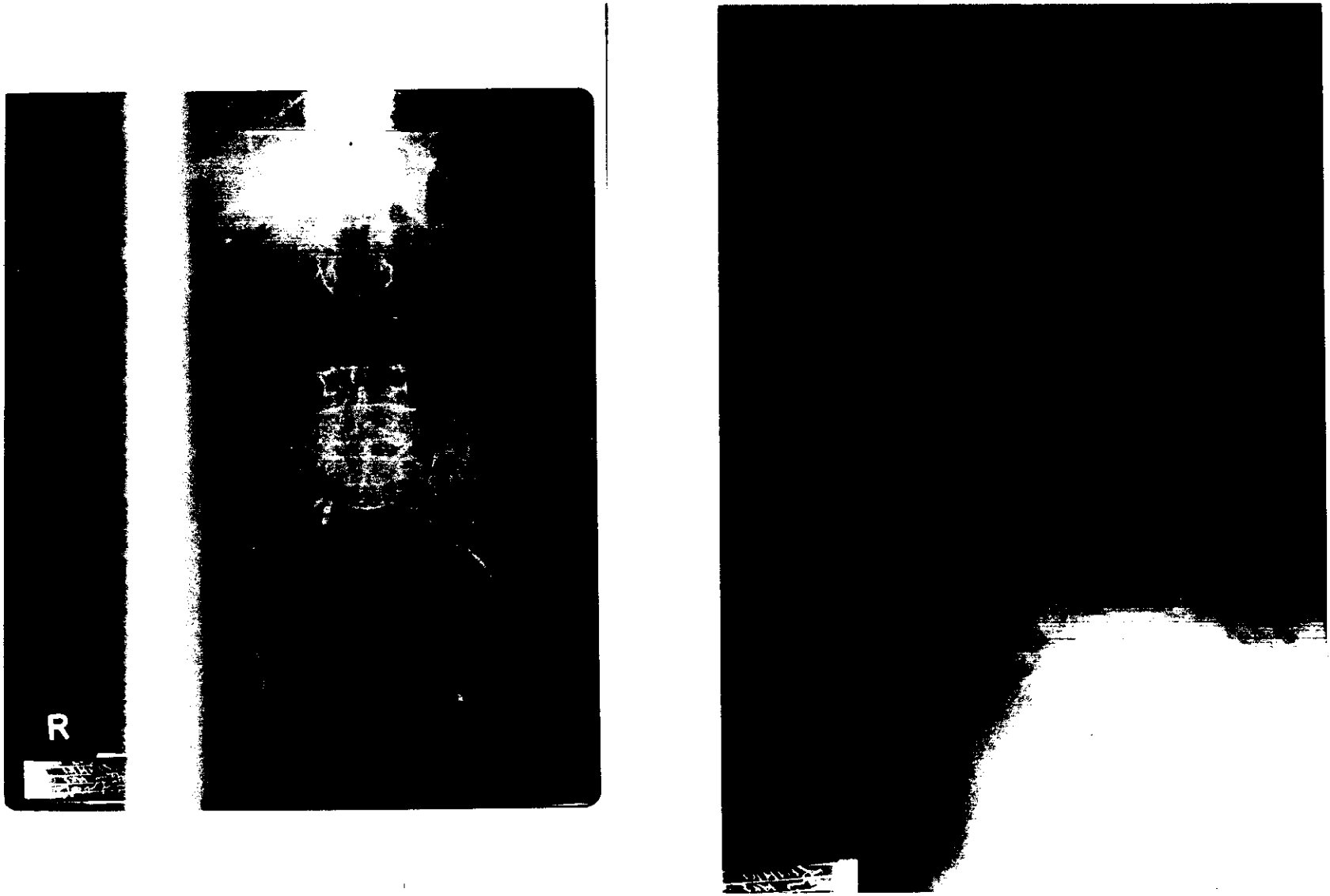
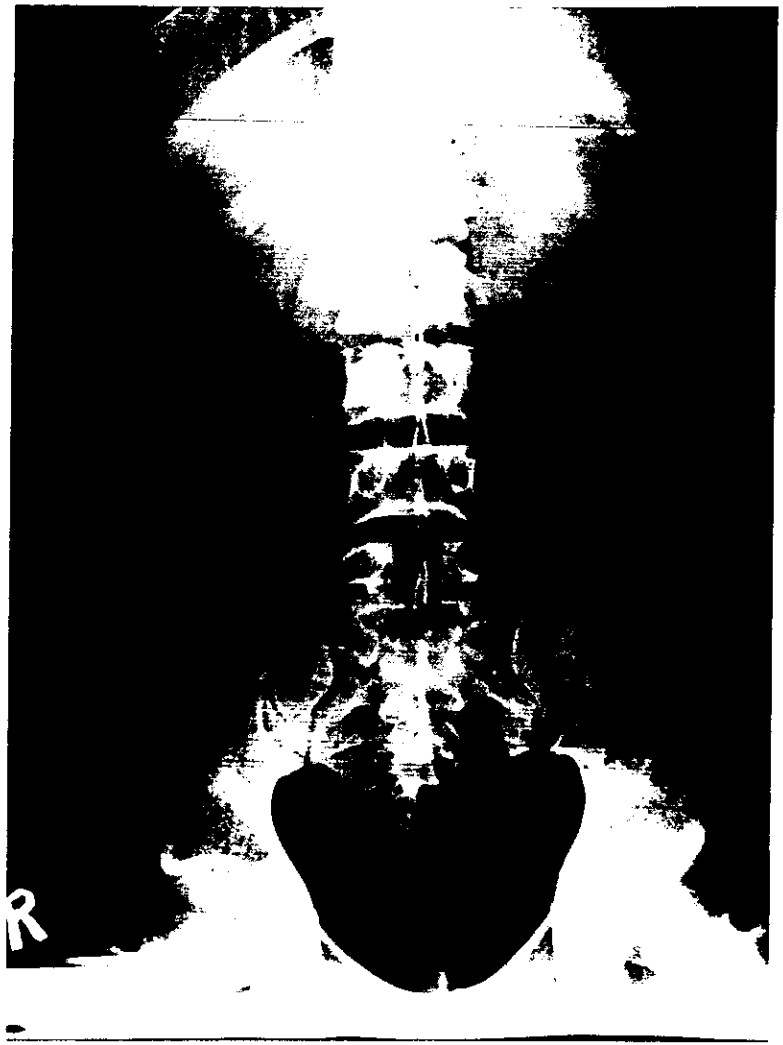


Figure 21 (continued), case No. 33



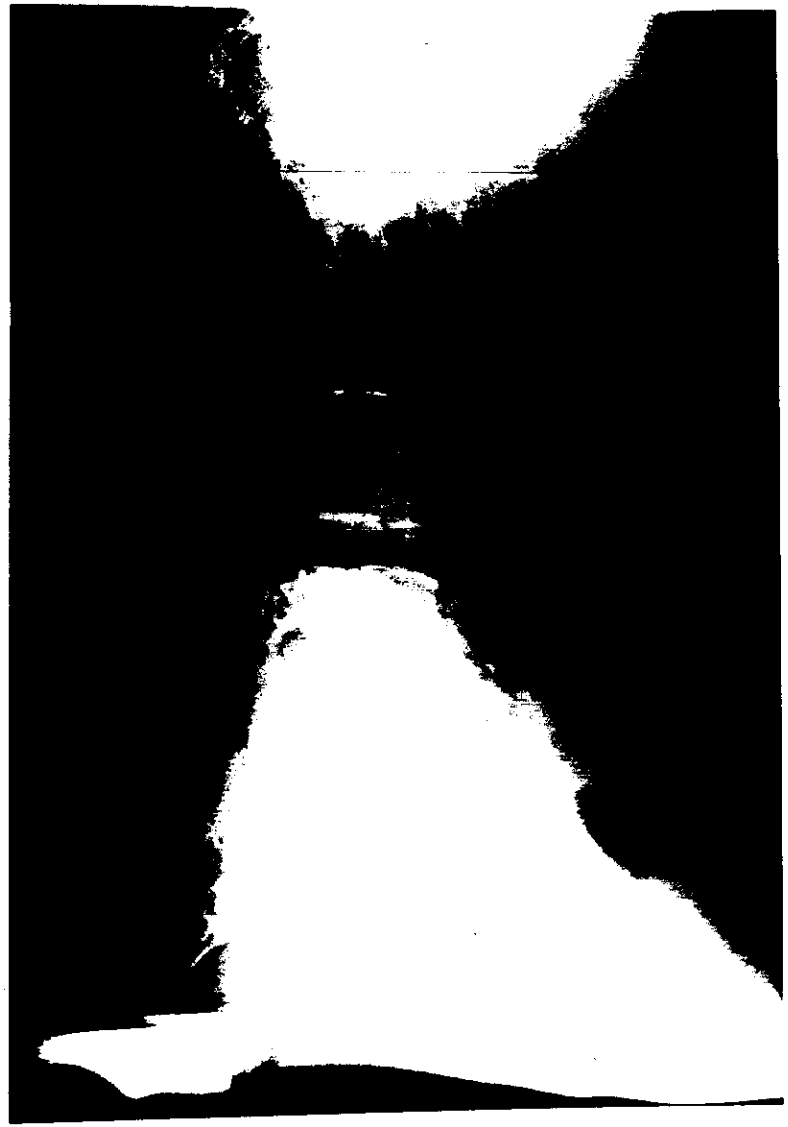


Figure 21 (continued), case No.47

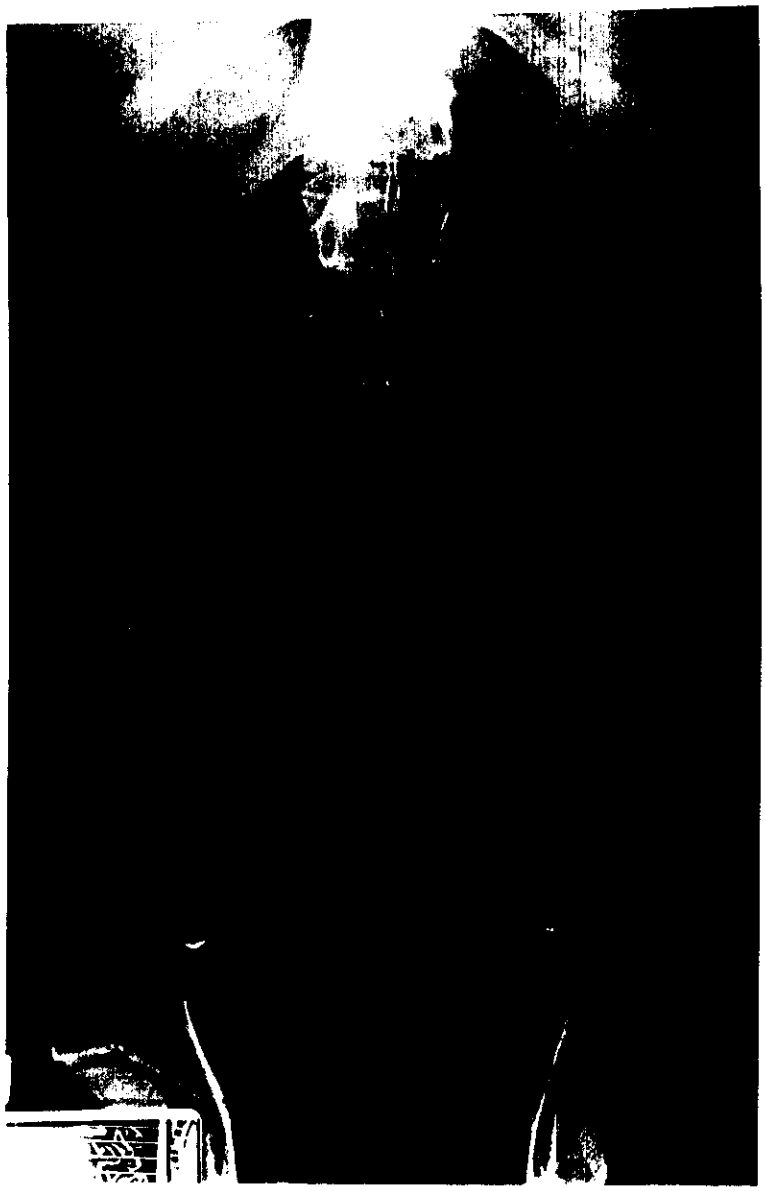


Figure 21 (continued), case No. 47

Examiner : A B C
Case No. : 47
Diagnosis :

History: Age : 45 Male

Complaint : Low back pain, of gradual onset, long duration, treated by laminectomy since four years nearly, localised, no radiation symptoms.

Examination : Old surgical scar at lumbar area.

Spasm : Paravertebral muscle spasm.
Tenderness : At L4/L5/S1 spines.
Range of Motion : Limitation of forward flexion.
Motor Power :
Sensation :
Reflexes :
SLR :
Pulse :

ESR : Normal.
Ca :
Phosphate:
SAP :
Others :

X-Ray: Laminectomy of L4, straightening of the lumbar spines

```
rule(1,"LBP","LBP, Child, Mech Der,Postural LBP *Bunnell,1982 ",[1000,1001,2000,
2001,3000,3001,4000,4001,4005,4100,4101])
rule(2,"LBP","LBP, Child, Mech Der,Muscle Strain *Bunnell,1982",[1000,1001,1002,
1003,1004,2000,2001,3000,3010,3012,4000,4001,4005,4100,4101])
rule(3,"LBP","LBP, Child, Mech Der,Herniated Nucleous Pulposus *Key,1950;Bradfor
d and Garcia,1971;Nelson et al,1972;Bulos,1973",[1000,1001,1010,2000,2001,2002,2
010,2020,2030,2040,3000,3010,3012,3020,3021,3040,3050,3060,3070,3080,3100,3105,3
110,3120,3150,4000,4001,4005,4100,4110,4110,4112,4500,4502,4850,4852,4900,4902])
cond(1000,"HIST . i.e HISTORY ")
cond(1001,"HIST . ----- Child")
cond(1002,"HIST . ----- Athlete")
cond(1003,"HIST . ----- Incorrect sport technique ")
cond(1004,"HIST . ----- Too rapid advances in activity without proper conditioni
ng")
cond(1010,"HIST . ----- Adolescent")
cond(2000,"C/O  . i.e COMPLAINT ")
cond(2001,"C/O . ------ Back pain ")
cond(2002,"C/O . ----- Back pain :- Is the c/o of .....          ")
cond(2010,"C/O . ----- Sciatica :- Is .....          .....")
cond(2020,"C/O . ----- Anticidental trauma :- Is present .....")
cond(2030,"C/O . ----- Gait disturbanace.....")
cond(2040,"C/O . ----- Onsit :-is always slower")
cond(3000,"O/E . i.e ON EXAMINATION  ")
cond(3001,"O/E . ----- Exclude other causes ")
cond(3010,"O/E . ----- MC - i.e Muscle Condition ")
cond(3012,"O/E . ----- MC - ----  spasm ")
cond(3020,"O/E . ----- SLR - i.e Strait Leg Raising ")
cond(3021,"O/E . ----- SLR - Limitation .....")
cond(3040,"O/E . ----- LL - i.e Lumbar Lordosis")
cond(3050,"O/E . ----- FF - i.e                ")
cond(3060,"O/E . ----- ScSc - i.e              ")
cond(3070,"O/E . ----- G - i.e                 ")
cond(3080,"O/E . ----- P - i.e                 ")
cond(3100,"O/E . ----- N - i.e                 ")
cond(3105,"O/E . ----- N - ---- Muscle tone              ")
cond(3110,"O/E . ----- N - ---- Motor power              ")
cond(3120,"O/E . ----- N - ---- Sensory changes          ")
cond(3150,"O/E . ----- N - ---- Reflexes changes         ")
cond(4000,"INV . i.e INVESTIGATION ")
cond(4001,"INV . ----- LAB . i.e Laboratory results")
cond(4005,"INV . ----- LAB . ---- Negative result")
cond(4100,"INV . ----- X-RAY  ")
cond(4101,"INV . ----- X-RAY ---- May be normal ")
cond(4110,"INV . ----- X-RAY ---- May be ---narrowing of the disc space")
cond(4112,"INV . ----- X-RAY ---- May be ---decreased in LL")
cond(4500,"INV . ----- Mye . i.e                        ")
cond(4502,"INV . ----- Mye . ---- Should be performed ---to substanciate the dia
gnosis ")
cond(4850,"INV . ----- EMG . i.e                        ")
cond(4852,"INV . ----- EMG . ---- In over 90% of the cases ---localise the nerve
 root involved ")
cond(4900,"INV . ----- CSF . i.e                        ")
cond(4902,"INV . ----- CSF . ---- Frequently ---shows increase in protein conten
t ")
topic("LBP")
```

Table 27: BACKEXPERT, 1989

This group of patients, with age ranging from 12- 70 years, (Table 25), (mean age 41 years); were selected to cover the different categories of low back pain syndrome, to evaluate the system.

Table 25: Age and sex distribution of the example patients

	Male	Female	Total	%
10-20 Years	3	1	4	8
20-30 Years	4	0	4	8
30-40 Years	6	1	7	14
40-50 Years	15	4	19	38
50-60 Years	4	6	10	20
60-70 Years	1	4	5	10
> 70 Years	0	1	1	2

21 patients were verified by laboratory investigations more than ESR, such as complete blood picture, rheumatoid factor, serum uric acid, serum alkalin phosphatase, etc.. .

Also, CT scanning was done for ten patients to assess their neurological manifestations, (Table 26). They were diagnosed as: five cases of nerve root compression, three neoplasm, one spinal stenosis, and the last one was myofascial strain, (Figure 21).

Table 26: Types of investigations and numbers of cases that need more than x- ray and ESR.

Investigation type	Number of the cases
* Imaging	
X- ray	50
CT	10
* Laboratory	
ESR	50
Others	21

The BACKEXPERT system was conducted by a single user to the example patients, with their data up to the results of the radiographic studies. The same data were subjected for assessment by the human experts, separately.

The single user performance of the BACKEXPERT system ,(Table 24), shows compatible diagnostic results with that of the human experts, if simillar data is presented.

The human expert shows its merit in simple and complex, i.e. more than one, diagnosis, as well as providing the suitable differential diagnosis.

As regards the system, it has its inference engine which provides these human capabilities in addition to perfect percentile weighing of each.

The system is accurate, suitable, with good specificity covering different aspects of low back pain syndrome, presenting efficient patient records, and provides good knowledge acquisition.

THE SYSTEM

Definition The system accomplished its definition. The computer based system used knowledge, facts and reasoning to solve the problems that normally require the ability of human experts.

The Incremental Construction of the System

Low back pain was the problem to be solved. The problem definition, good knowledge acquisition of the syndromes and artificial intelligence, review of many literatures, and personal communication determined that expert system technology is appropriate. It provided differential diagnosis with no need for categorizing or classification of individual diagnosis. The rule-based system used rules to represent knowledge and consist of collection of antecedent- consequent rules. The rule-based systems encoded the knowledge critical for decision making in the form of individualized reasoning rules. Heuristics, rules of thumb, if-then rule techniques activated the program by a control structure only when certain conditions were met.

The basic ES skeleton (shell) was constructed, (Table 27), and a small knowledge-base was developed, tested, and approved by the domain expert. The expert interaction, deletion, addition, modification and running of the program incrementally enhanced the small ES to provide all the services it was initially intended to provide, (Table 28).

This system provides numerous benefits

- The ability of incrementally construction
- The ability to run the system throughout all the preparation stages.
- The ability to alter one entity in the knowledge-base without affecting other entities in the knowledge-base.
- The program helps the technique of acquisition of data.

```
rule(1,"LBP","LBP, Child, Mech Der,Postural LBP *Bunnell,1982 ",[1000,1001,2000,
2001,3000,3001,4000,4001,4005,4100,4101])
rule(2,"LBP","LBP, Child, Mech Der,Muscle Strain *Bunnell,1982",[1000,1001,1002,
1003,1004,2000,2001,3000,3010,3012,4000,4001,4005,4100,4101])
rule(3,"LBP","LBP, Child, Mech Der,Herniated Nucleous Pulposus *Key,1950;Bradfor
d and Garcia,1971;Nelson et al,1972;Bulos,1973",[1000,1001,1010,2000,2001,2002,2
010,2020,2030,2040,3000,3010,3012,3020,3021,3040,3050,3060,3070,3080,3100,3105,3
110,3120,3150,4000,4001,4005,4100,4110,4110,4112,4500,4502,4850,4852,4900,4902])
cond(1000,"HIST . i.e HISTORY ")
cond(1001,"HIST . ----- Child")
cond(1002,"HIST . ----- Athlete")
cond(1003,"HIST . ----- Incorrect sport technique ")
cond(1004,"HIST . ----- Too rapid advances in activity without proper conditioni
ng")
cond(1010,"HIST . ----- Adolescent")
cond(2000,"C/O  . i.e COMPLAINT ")
cond(2001,"C/O . ------ Back pain ")
cond(2002,"C/O . ----- Back pain :- Is the c/o of .....                    ")
cond(2010,"C/O . ----- Sciatica :- Is .....                  .....")
cond(2020,"C/O . ----- Anticidental trauma :- Is present .....")
cond(2030,"C/O . ----- Gait disturbanace.....")
cond(2040,"C/O . ----- Onsit :-is always slower")
cond(3000,"O/E . i.e ON EXAMINATION  ")
cond(3001,"O/E . ----- Exclude other causes ")
cond(3010,"O/E . ----- MC - i.e Muscle Condition ")
cond(3012,"O/E . ----- MC - ----  spasm ")
cond(3020,"O/E . ----- SLR - i.e Strait Leg Raising ")
cond(3021,"O/E . ----- SLR - Limitation .....")
cond(3040,"O/E . ----- LL - i.e Lumbar Lordosis")
cond(3050,"O/E . ----- FF - i.e                ")
cond(3060,"O/E . ----- ScSc - i.e              ")
cond(3070,"O/E . ----- G - i.e                 ")
cond(3080,"O/E . ----- P - i.e                 ")
cond(3100,"O/E . ----- N - i.e                 ")
cond(3105,"O/E . ----- N - ---- Muscle tone                    ")
cond(3110,"O/E . ----- N - ---- Motor power                    ")
cond(3120,"O/E . ----- N - ---- Sensory changes                ")
cond(3150,"O/E . ----- N - ---- Reflexes changes               ")
cond(4000,"INV . i.e INVESTIGATION ")
cond(4001,"INV . ----- LAB . i.e Laboratory results")
cond(4005,"INV . ----- LAB . ---- Negative result")
cond(4100,"INV . ----- X-RAY  ")
cond(4101,"INV . ----- X-RAY ---- May be normal ")
cond(4110,"INV . ----- X-RAY ---- May be ---narrowing of the disc space")
cond(4112,"INV . ----- X-RAY ---- May be ---decreased in LL")
cond(4500,"INV . ----- Mye . i.e                                      ")
cond(4502,"INV . ----- Mye . ---- Should be performed ---to substanciate the dia
gnosis ")
cond(4850,"INV . ----- EMG . i.e                                      ")
cond(4852,"INV . ----- EMG . ---- In over 90% of the cases ---localise the nerve
 root involved ")
cond(4900,"INV . ----- CSF . i.e                                      ")
cond(4902,"INV . ----- CSF . ---- Frequently ---shows increase in protein conten
t ")
topic("LBP")
```

Table 27: BACKEXPERT, 1989

Specification Of The System

- It is composed of elven files, providing twinty functions and subfunctions.
- Decision trees convey, objective, measurable, and relevant clinical findings to which a measurable objective assessment of diagnosis of the problem could be reached.
- It develops intelligent inferences from heuristic knowledge.
- It is not meant to be a rigid system but merely a framework by which it might be expanded for evaluation and care of all orthopaedic cases.
- If the solution (diagnosis) is not definite by acceptable probability, the system would articulate the rules and facts it used in developing the recommended investigation required.
- The system justify its answers or advice by providing an ordered list rules and facts it used its answer. No need for separate explanatory facility as the user will get that via revisit stage of the data file for any patient, at once.
- Ability to receive commands and information in its skeleton for current updating.
- It has an inference design to develop a filing system for personal data.
- The system is utilized to collect clinical data in a methodical way and complete in order to provide a more individualized diagnostic approach.
- The system provides a complete reference on numerous data for low back pain examination that covers the basic principles.
- An accessible-designed to be a hands-on-reference.
- Increased personal litigation has led to an ever increased number of medico-legal reports. This system will simplify report writing for all the users.
- Clearer guidelines on the preparation and format of reports covers both the medical and legal aspects as it provides a written referenced pathway of the used conditions with their references to reach a definite diagnosis or plane of management.
- It takes over record keeping at all, though provides data for teaching, research, or statistical studies.
- Its record keeping exceeds the quality of manual record.

User-Computer Interface

The two common operational modes in programming the user-system interface are consultation and acting as a teacher, (Table 29). Both are represented and considered to be the user manual for identification of the system.

Advantage

Innovation

- It accepts any knowledge via its inheretent wide future lock in the design of the implemented shell.
- It could be completely revised, updated and expanded to involve the detail of the latest techniques for management of low back pain.
- it could be more up-to-date, more accessible, more economical than an orthopaedic textbook.

Trainee and specialist

It offers a complete program of education and seclf- assessment for the low back pain examination trainee. Also it is comprehensive and systematically organized bench diskette for the practicing specialist using personal computers. It may also serve as a bases for review of complex cases. It is of good use in memorizing diagnosis of rare cases.

Experience capabilities

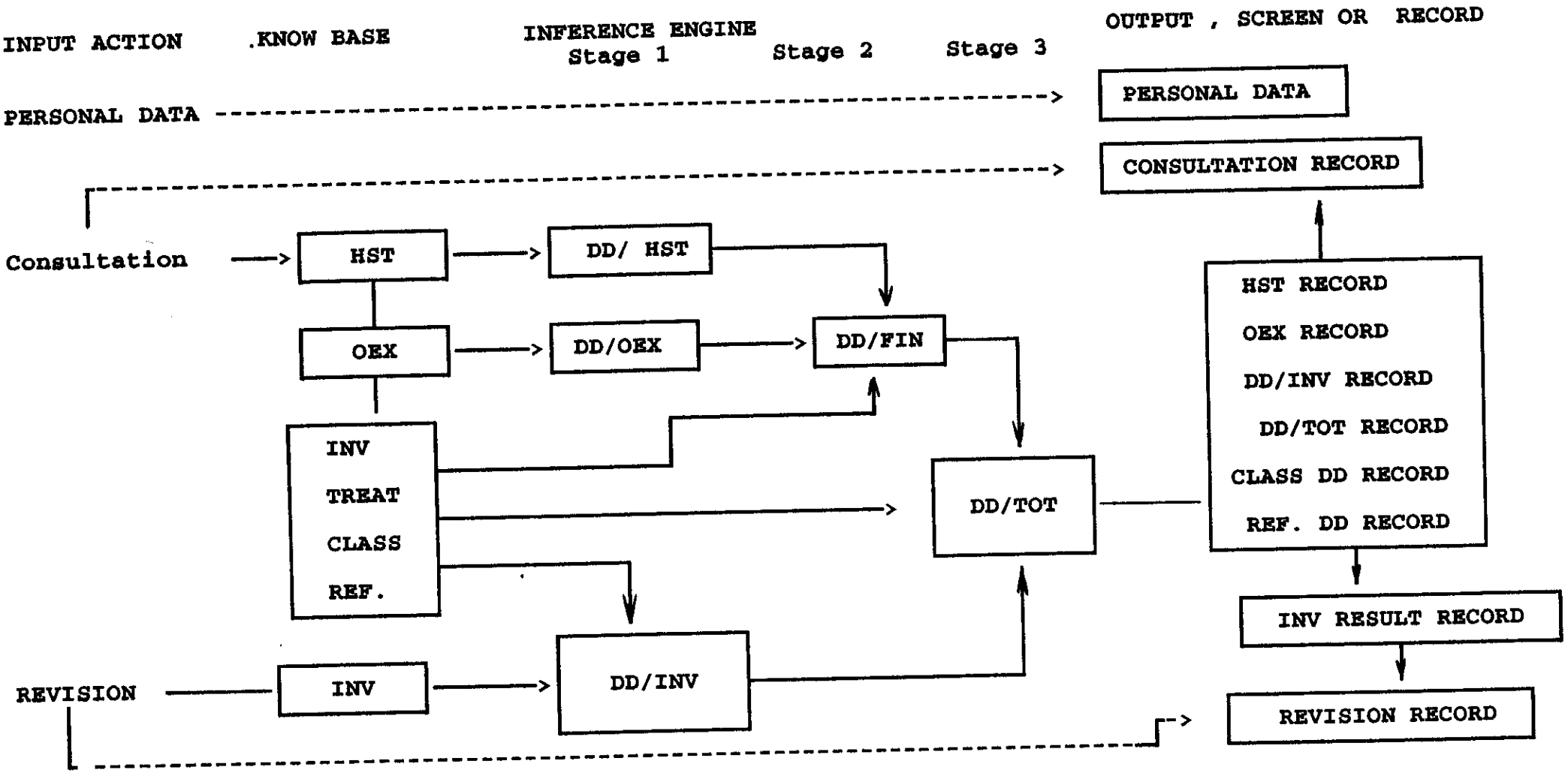
Besides giving information in the process of management of low back pain, the system offers problem resolving power. It stimulate the user to construct his own decision based on the experience, capabilities, and the intelligence of the expertise. It is not dependent on the operator skill capability.

Difficulties

Technological development cost extra money and effort

Building an expert system is expensive and need budget. This project is a team effort requiring interaction between different highly skilled personnel who are highly paid.

TABLE: 29



BACKEXPERT:

Consultation and Revision Task
Knowledge Base
Inference Engine
User Interface

Lack of current expertise

Because of the novelty of the artificial intelligence, it is difficult to obtain the suitable knowledge engineer to perform this special manner like that, low back pain diagnosis and management.

Time consuming

The time necessary for recording and analysing one case can be minimized. The more the experience the user will have with such program the time decreased.

Medical Information Technology

In low back pain diagnosis and management, the medical information was used to serve this domain in two main cmponents: consultation and revisit stages.

User-computer interface

The consultation for patients complaining of low back pain is maintained. Also, acting as a teacher is provided. Both tasks are presented throughout a wide scope of user-computer interface, (Figure 22).

Personal data

It is optional, but necessary for identification for any case of consulting and revision, (Figure 23). It is separate entity program and could be used alone for patient registration in any clinic or department. It is easy to recall for screen revision or printing using the name or the number of the patient. It accept addition for any number of patients.

Consultation

The user can enter the consultation process which contains clinical history, examination, recommended investigation, treatment, classification and references. The user can read old consultations, (Figure 24), also by the names or numbers of the patients. Following the classic, and more recent data necessary to collect the relevant data of history and clinical examination process, the user is invited to look, think and choose.

Medical history, (Figure 25), and clinical examination screens, (Figure 26), will appear sequentially. The screen will continue until the user finish all the head lines or escape the windows. Each head line, if entered, will lead to another window containing new items related to the head.

The program will display the selected items from the root node (head line), until the leaf node (end node) of each way, (Figure 27- 33).

The user, so, will be not obliged to scan all the data base which he is not in need, he will by-pass what is not selected. So, the user interface is directed to the computer, which is also dynamic to accomplish good user- computer interface. This dynamic approach save user's time, eye strain, and mental stress. The direct user-computer interface saves the need to assistant or receptionist to type a questionnaire results, if used, decrease errors and revision time. Whatever the user enter a previously selected item, the computer will follow the order, but no registration, printing for this repeated item, and also no calculation errors.

Following history assessment, and at the end of the clinical assessment there will be the differential diagnosis, (Figure 34), in each, and final differential diagnosis, (Figure 35), by summation of both with availability to interact again with the advice recommendations.

Revisit stage

The patient must be registered before, in the consultation stage, to revisit, either the user will have empty consultation record.

The user will have, on revisit stage, (Figure 36), firstly all data that had been taken at the previous stage, consultation, with all the process: differential diagnosis, recommended treatment etc.... for the history, then the clinical examination then final of the two. This quick revision will prepare the user to meet the revisit state with full record and reminder about the given treatment and recommended investigation. Now he will scan the investigation data, (Figure 37- 40), to enter the laboratory, radiological, or other findings to produce the total differential diagnosis.

The inference engine will interact with the new data to produce again the new advice or recommendations, (Figure 41,42). Consultation number considered to be the reference for any numbers of revisits until the condition is relieved completely.

Investigation

It is optionally presented for both expert and the user. It can be used at the usual daily work, either the condition was in use for consultation, revisit, (Figure 43- 48), or not, (Figure 42, continued). It could be used as advisor, or printing investigation requests, according to the built in program.

This window display the name, number of the patient to be written, as a separate record and accessory benefit of the program.

Subsequent lists of all the available low back pain syndromes, arranged categorically, (Figure 42), to choose one disease, to get the recommended investigation, or more than one in case of teaching or a reminder facility. Pressing "escape" key will show the results of the entered diseases. The user can get a self-teaching, by entering all what he need.

Treatment

It is optionally providing the user with the general lines of treatment in case of a preconsulted patient, teaching, or as a reminder, (Figure 49- 52).

It could be used, also separately for printing any prescription, according to the entire data. This facility also has the list for easy use and to decrease errors.

Reference

It is optionally, enabling the user to read one reference or more with abstract, (Figure 53- 54). The user can read and print what he need by number or name of the author.

The user himself can interact with the program directly and add what he need of references by entering: add facility., following the screen orders will add the user's recommended references for following benefits.

The user can read or add any reference abstract or even a complete text and also to get a print out.

Classification

It is important to know the classification of some diseases, specially in case of degenerative, inflammatry, or neoplasm for example, (Figure 55).

Help

It is optional. It is designed as a user help for running the program efficiently and to explore its benefit, i.e. manual. Some problems which may face the user could be displayed and its solution shown.

Expert Notes

It is optional. It is considered to be a user interface or the expert to write his comment, new foundation, data, or any recommendation. These notes will be collected, rearranged and added to the data base and knowledge base for continuous innovation and maintenance which is one of the specifications of an experts system. They could be recalled for read, addition of new, or printing.

Exit

It provides easy outlet of the program to the DOS, and guarded by an awareness statement.

Print out

Throughout all the process, the user can use the facility of printing any documentation, either directly from the screen or ordering in the station point itself.

Medical Communication

The system is considered to be a way of medical communication. It supports the related terms of communication: education, teaching and instructions. Via computer, messages can be transmitted from sender to receiver.

Medical Practice

The system takes an opportunity through its design which modify the scientific bases of medical practice.

It adopts a heurestic approach which helps to raise the user's abilities in solving the medical problems. It provides useful way for gathering medical knowledge: diagnosis, investigations and planning for treatment.

- The user is encouraged to follow detailed expert historical techniques, so no missing of valuable historical information.
- Following a regional and selected-organized order of examination is adopted by the system to fulfill comprehensive screening examination.
- The investigation that yield the most comprehensive information and carry the l east risk for the patient were selected. The diagnosis frequently become apparent with simple tasks; more expensive or potentially hazardous studies may not be required. It limits the random request, and the error of misinterpretation of results especially in rare cases.
- Then the system helps the user to evaluate and provides him by the results of matching both the data received from the investigation and the information acquired from the patient offering easy accurate and fast calculation.
- The system learns the user the cognitive or intellectual skills needed in formulating a diagnosis or problem definition. It offers knowledge of medical facts needed for analysing information. Its mechanism is to collect information and synthesizing it into integrated concepts compatible with known diseases. It weighs the diagnostic possibilities by calculating the resultant positive facts to reach the most likely diagnosis. It is not easy to calculate those possibilities, but the system does, and offer a descending percentile list for them by scanning, not by exclusions. According to these values the system provides the user the suggested investigations. The steps that had been taken, i.e. the way of thinking, is recorded also.

Medical Care

Medical care could be maintained through computerized medical record, and registration. The records will be offered at the screen automatically while doing the

clinical examination steps and is available at the end of consultation for revision or printing. Time, and medical revision of a patient file become much less. Office automation facilities become better.

Decision Support

The user gets a decision support for his clinical decision making from data gathering and data interpretation. The system accepts numerous data gathering and provides data interpretation using heurestics and rules of thumb. It enhance the learning experience in the field of recommended investigation studies, and interpretation.