Computer Diagnosis of Skin Disease

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A transferable computer program for the differential diagnosis of diseases of the skin, CLINDERM, has been produced for use by physicians on standard IBM and compatible personal microcomputers. This program lists the differential diagnosis and definitive diagnosis of any presented disease of the skin, except single tumors. The physician operator indicates the distribution and detailed description of lesions, which the interactive system integrates with a comprehensive knowledge base.

The computer diagnosis in 129 cases was compared with independent interpretation of the same information by an academic dermatologist. Results were synonymous in 66.7% of all diseases and similar in an additional 4.7%. A common differential diagnosis was obtained in 24%, for a 95.3% rate of synonymous, similar, or common differential diagnoses. Diagnosis was different in 3.9% and description was inadequate for diagnosis in 0.8%.

The variation in diagnosis showed that some descriptive terms are prejudicial of certain diagnoses; that diagnostic terms are not all completely standardized; that some diagnoses are variants of another disease; and that drug-induced eruptions simulate many other diseases.

A skin disease can usually be diagnosed by specific description. Most lesions that are not diagnostic from inspection are nodular. A computer can be programmed to list diagnoses according to morphologic description **J FAM PRACT 1990; 30:201-210.**

A functional, transferable computer software system for the differential diagnosis of diseases of the skin, called CLINDERM,* has been produced for use by physicians on standard International Business Machines (IBM) and compatible personal microcomputers. The program will list the differential diagnosis and render a definitive diagnosis of any disease of the skin except single tumors. It is of considerable assistance in clinical decision making and can provide a reliable, systematic differential diagnosis.

Dermatologists diagnose an eruption by the subjective assessment of perceived abnormalities. This assessment is then compared with the knowledge and experience in memory. The empirical data obtained from a physical examination may, however, be excessively complex. Objectivity is improved by recording specific features according to sets of standardized criteria. This information can then be analyzed.

Such a process can be programmed; in other words, any logical procedure can be stated as a series of instructions to a computer. A procedure must be formulated explicitly, however, in order to be programmed.

While medical knowledge has almost always been published as concepts of a disease or groups of diseases involving certain systems of the body, much less of the literature has been organized from the point of view of symptoms and signs leading to diagnosis. Medical knowledge must be arranged in this way for computer diagnosis.[1]

Several works on diseases of the skin have classified primary cutaneous findings in ways that lead to diagnosis secondarily. These aids to diagnosis have been based on the morphology of the eruption and noneruptive lesions[2]; the pattern of distribution, regional localization, configuration, and morphology of lesions[3]; observation of the most prominent lesion and other pertinent characteristics[4]; identification of the clinical pattern and prediction of the cutaneous level of involvement[5]; problem-oriented

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algorithms starting with the patient's presenting complaint, signs, and symptoms[6–8]; and sequential histopathological analysis.[1]

Previous systems for computer diagnosis of diseases of the skin have recently been reviewed.[9]

THE CLINDERM SYSTEM

First, in creating the CLINDERM program, all the principal and characteristic diseases of the skin were resolved into several common, elementary cutaneous forms. These elementary forms represent the primary lesions, which are monomorphous by definition. The lesions reflect the limited number of ways in which the skin can respond to a pathologic stimulus. Although lesions can occur independently—for instance, a nodule—they are typically multiple and compose the eruption, or rash.

An eruption is composed of individual lesions that exist for variable periods of time. One eruption can be distinguished from another by the morphology and the distribution of the lesions. An eruption may be either monomorphous or polymorphous.

Lesions constitute a second general category of cutaneous pathologic processes, namely, the noneruptive disorders of the skin, hair, nails, and mucous membrane. Noneruptive disorders include discoloration, hypertrophy, atrophy, and degeneration, all of which may be of indefinite duration.

Any eruption or noneruptive disorder of the integument can be characterized by the distribution on the skin, scalp, nail, or mucous membrane and by the combination of lesions exhibited. In this way a logical description of the diseases of the skin was listed in a comprehensive knowledge base and organized into a formal representation of cutaneous medicine.

The name of a disease may occur several times in the knowledge base and within different sets of differential diagnosis, because a disease may become manifest in several fashions, for instance, both macular and scaly, or either localized or extensive. The number of different diseases in the knowledge base is 548, but the total number of all the diagnoses in the system is 1256. To reach any diagnosis requires a maximum of 9 nodes to be passed through.

The CLINDERM system can accept any case presented for diagnosis and will allocate each case to a disease class. Multiple nodular lesions that occur in the form of an eruption have been included, but individual tumors have been excluded because such nodular lesions require biopsy and histopathologic interpretation for definitive diagnosis. Previous studies have shown the accuracy of clinical diagnosis of common skin tumors from criteria tables to be about 80%.[10] The diagnosis of basal cell epithelioma from clinical examination is correct in only 56% to 73% of cases.[11] A clinical, gross, morphological diagnosis of neoplasms and granulomas obviously cannot be made with certainty.

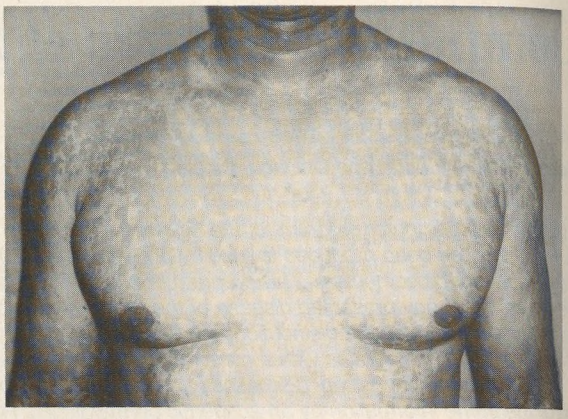


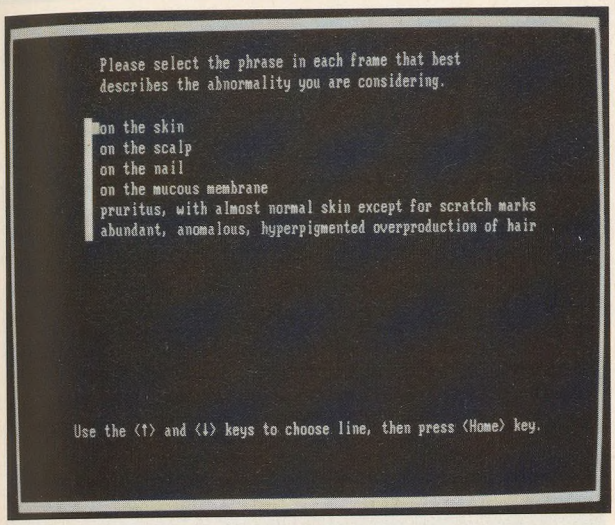
Figure 1. Patient with an eruption to be analyzed.

After the specialized information has been incorporated into the computer memory, this knowledge and experience can be applied to individual cases. The second class of data required to reach a diagnosis is an adequate description of the abnormality exhibited by the patient. There must be a procedure to collect this information.

Contemplation of the algorithmic nature of computer programs suggests that the optimal method of computer diagnosis should take advantage of the branching characteristic of machine languages. By selections from the knowledge base on the computer screen, the physician can indicate a complete description of the eruption. The process leads through a relevant sequence until the diagnosis is reached.

CLINDERM is the functioning system utilized to generate the differential diagnosis and to ensure that none has been overlooked. The indications for the use of the system are to list the differential diagnoses and render the definitive diagnosis of diseases of the skin. In its application in a medical setting, the process is interactive. The physician represents the interface between the appearance of the patient and the computerized knowledge base.

To illustrate the procedure, a photograph of an eruption is shown in Figure 1. The abnormality is of the skin, so "on the skin" would be chosen from the first display on the computer screen (Figure 2, left). This selection causes the computer to take two actions: first, to place this line in its temporary memory in an array of phrases descriptive of this patient; and second, to display a list of primary



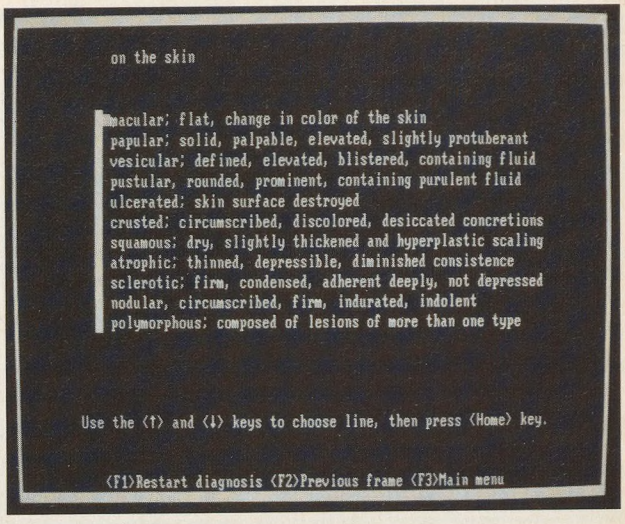
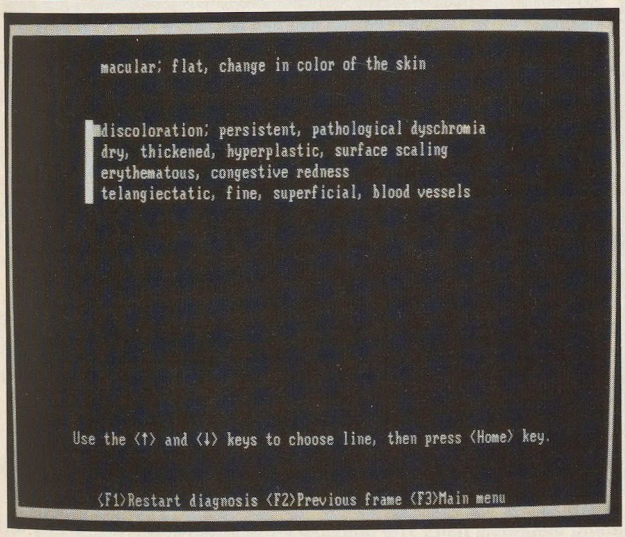


Figure 2. The chosen line is placed in an array of phrases (left), descriptive of this patient, in temporary memory. This is followed by a list of primary lesions (right).

lesions (Figure 2, right). From this list "macular; flat, change in color of the skin" would be selected, as this description corresponds to the abnormality shown in the photograph. The chosen phrase is automatically added to the descriptive array.

The computer then displays a further list of alternative findings (Figure 3, left), from which "discoloration; persistent, pathological dyschromia" is selected, followed by, "leukodermic, achromic hypopigmentation" (Figure 3, right).

The disease manifests itself in an extensive distribution. In Figure 4, left, the corresponding line that the operator selects is added to the description. If more than one description could be applied, either or both can be chosen in turn, as the diagnosis will be listed under alternative specifications.



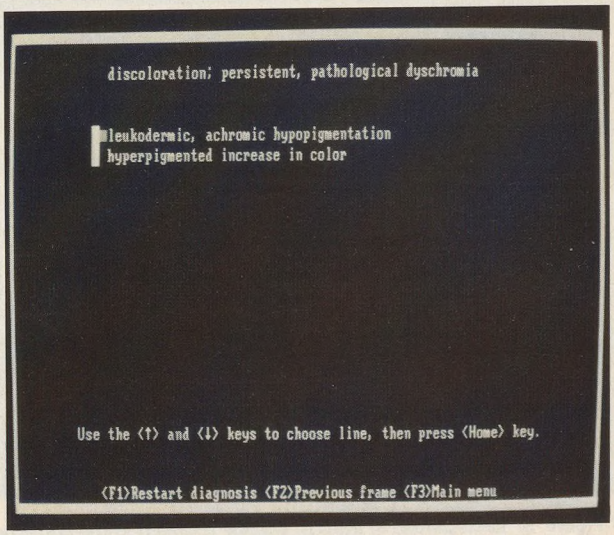


Figure 3. Analysis of macular lesions (left). The phrase selected in each display appears at the top of the next screen (right).

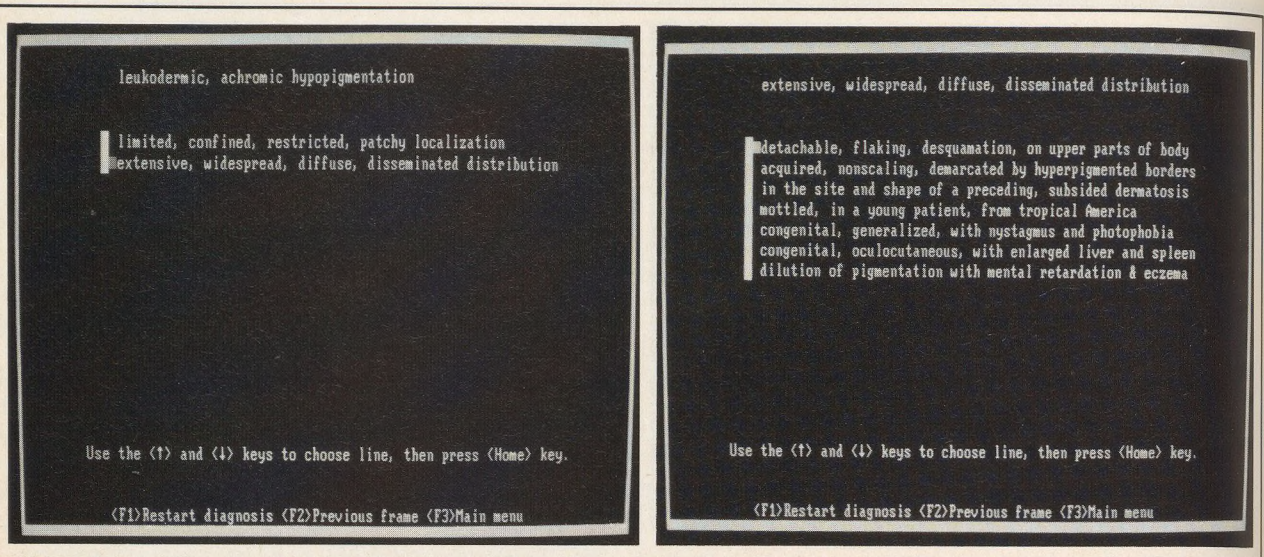


Figure 4. The information already obtained is sufficient to include tinea versicolor in the differential diagnosis (left). One more screen (right) is required to exclude other possible diagnosis.

The amount of information already obtained is sufficient to include tinea versicolor in the differential diagnosis but is insufficient to exclude other possible diagnoses. One more menu is required to do so (Figure 4, right) in which each phrase is linked to the corresponding diagnosis in Figure 5, left.

The machine now recapitulates the descriptive phrases and the diagnosis that the phrases indicate (Figure 5, right). The operator may choose to print any or all of the differential diagnoses.

The objective description and diagnosis are then combined with personal information. Individual features that may be noted in the history or examination and a treatment plan may be added to the consultation report.

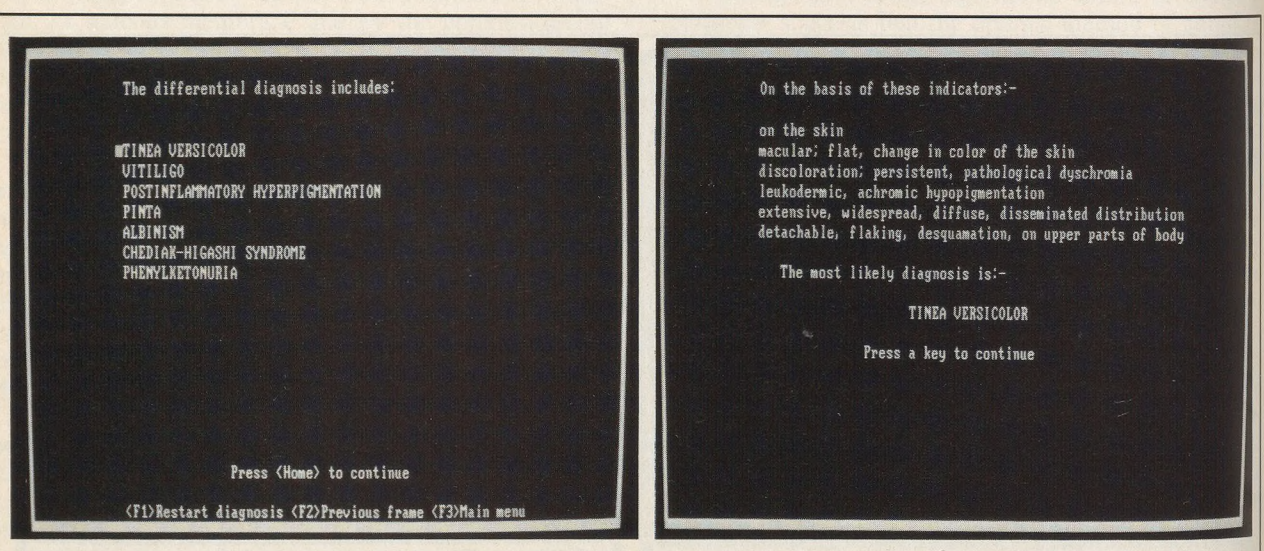


Figure 5. Each phrase in the last display is linked to the corresponding diagnosis (left). The machine recapitulates the descriptive phrases and the diagnosis that they indicate (right). The operator may choose any or all of the differential diagnosis.

THE MEDICAL GROUP
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DERMATOLOGICAL CONSULTATION

NAME OF PATIENT:

DATE: 05-17-1988

COMPLAINT: loss of skin color

DURATION: four months

OCCUPATION: laborer

AGE: 34

FAMILY HISTORY: none

SEX: male

TOPICAL APPLICATIONS: vitamin E cream

MARITAL STATUS: single

ALLERGIES: none

FILE #: 88-1829

CURRENT MEDICATION: none

REFERRAL:

HISTORY:

OBJECTIVE DESCRIPTION:

Examination of the patient shows that the dermatological findings are on the skin; macular; flat, change in color of the skin; discoloration; persistent, pathological dyschromia; leukodermic, achromic hypopigmentation; extensive, widespread, diffuse, disseminated distribution; detachable, flaking, desquamation, on upper parts of body.

DIFFERENTIAL DIAGNOSIS:

TINEA VERSICOLOR
VITILIGO
POSTINFLAMMATORY HYPERPIGMENTATION
PINTA
PHENYLKETONURIA

DIAGNOSIS:

TINEA VERSICOLOR

TREATMENT:

DATE OF REPORT: 05-17-1988

Brian Potter, M.D.

Figure 6. The report is printed automatically, utilizing the information obtained.

The report is now printed automatically (Figure 6), using the information obtained on a form displaying the name and address of the office or clinic, personal data, history taken, objective description, differential diagnosis, definitive diagnosis, treatment plan, the date, and the name of the physician. After the report has been proofread, any typographic errors that are found may easily be corrected. The report may be reprinted any number of times.

The patient's name and file number may be preserved for future reference, combined with the diagnosis, to enable future sorting, listing, and searching. These items are added to an archive or cumulative list of these items.

METHODS

The accuracy of each computer diagnosis of 129 cases of skin diseases was validated by comparison with independent interpretation of the same information by an academic dermatologist who had no prior connection with the construction of the knowledge base or with the system design. The objective descriptive sections of the case reports were forwarded to the dermatologist, who was asked to write a differential diagnosis and to indicate the definitive diagnosis. The dermatologist's interpretation was based therefore only on the age and sex of the patient and the description of the disease that was compiled by the computer from the indications of the operator.

The first 107 cases were taken from patients in the senior author's clinical practice and included ambulatory patients and hospital consultations. All the patients presented new cases of an eruption or noneruptive lesions. The patients were taken consecutively until known duplicate diagnoses were encountered; the duplicate was then eliminated from the study, and the next new patient was selected.

When a series of over 100 patients had been accumulated, most of the diseases being encountered were duplicates of diagnoses already included in the study. Another 22 were therefore taken from published reports of unusual or rare cases not actually seen by either of the authors. To this extent, some were patients of tertiary care facilities. The total number of individual cases was 129, with 122 different diagnoses.

Cases of patients presenting with common, recognizable nodular lesions such as seborrheic keratoses, warts, and nevi were included in the study, as ordinarily such lesions would not all be submitted to biopsy. The only cases excluded from the study were those of nodular lesions considered to need a biopsy for definitive diagnosis. Such lesions comprised chiefly neoplasms, granulomas, and other individual nodules.

The cases were not otherwise limited because the computer system covers the entire domain of dermatology. Since all cutaneous presentations can be analyzed in terms of their primary lesions, any case could be accepted and a differential diagnosis given. The patients presenting with a single cutaneous tumor were eliminated, however, because in these cases discriminating features are notoriously lacking. All the possible diagnoses of an individual tumor could conceivably be given, but such lists become inordinately long.

RESULTS

When the computer diagnoses were compared with those of the dermatologist, they were found to be synonymous, similar, common within the differential diagnosis, or different. A summary of the results of the validation is given in Table 1.

In 95.3% of the cases, the computer and the dermatol-

TABLE 1. RESULTS OF VALIDATION

Results	Number	Percent
Dermatologist and computer made synonymous diagnosis	86	66.7
Similar diagnosis of marginally different significance	6	4.7
Common differential diagnosis	31	24.0
Dermatologist and computer made different diagnoses	5	3.9
Description inadequate for diagnosis by dermatologist	1	0.8
Total	129	100

TABLE 2. COMPUTER- AND DERMATOLOGIST-DETERMINED SIMILAR DIAGNOSES OF MARGINALLY DIFFERENT SIGNIFICANCE

Computer	Dermatologist
Acne conglobata	Cystic acne
Atopic dermatitis	Lichenified chronic eczema
Blastomycosis	Deep fungus infection
Contact dermatitis	Eczema
Lichenoid purpura	Purpura pigmentosa chronica
Stevens-Johnson syndrome	Erythema multiforme

ogist made a synonymous or a similar diagnosis, or presented a common differential diagnosis. More than two thirds of all the skin diseases were diagnosed synonymously. Most of these were diseases that manifest themselves with an eruption.

In 66.7% of all the diseases, the dermatologist's diagnosis was synonymous with that of the computer. The eruptive disorders in which the dermatologist agreed with the computer's diagnosis comprised acne vulgaris, acrodermatitis continua, asteatotic dermatitis, autoeczematization reaction, bullous pemphigoid, candidiasis, dermatitis herpetiformis, dermographism, diaper dermatitis, dyshidrosis, disseminated superficial porokeratosis, eczema, epidermolysis bullosa simplex, epidermolysis bullosa dystrophica, erythema infectiosum, erythema multiforme, erythema toxicum neonatorum, exfoliative dermatitis, folliculitis, herpes genitalis, herpes simplex, herpes zoster, impetigo, insect bites, intertrigo, lichen planus, lichen sclerosus et atrophicus, lupus erythematosus, necrolytic migratory erythema, neurodermatitis, nummular eczema, paronychia, perioral dermatitis, perlèche, pityriasis rosea, polymorphous light eruption, pretibial myxedema, pseudofolliculitis barbae, psoriasis, pustular psoriasis, rosacea, seborrheic dermatitis, stasis dermatitis, steroid-induced purpura, telangiectasis macularis eruptiva perstans, tinea versicolor, urticaria, vasculitis, and vulvovaginitis.

The noneruptive lesions diagnosed synonymously by computer and dermatologist included acanthosis nigricans, alopecia areata, anetoderma, aplasia cutis congenita, condyloma accuminata, dermatosis papulosa nigra, epidermal nevus, giant pigmented nevus, ichthyosis vulgaris, keratosis pilaris, male pattern alopecia, melasma, myxedema, nevus anemicus, nevus araneus, nevus depigmentosus, nevus flammeus, nevus sebaceus, onychogryphosis, pigmented hairy nevus, porokeratosis, telogen effluvium, and vitiligo.

In only nine of the 86 synonymous diagnoses were the lesions nodular, included because biopsy was not considered essential for diagnosis. The nine were blue nevus, cavernous hemangioma, dermatofibroma, epidermal inclusion cyst, granuloma annulare, keloid, molluscum contagiosum, pyogenic granuloma, and verruca vulgaris.

In six cases (Table 2) the computer's and dermatologist's diagnoses were similar, but of marginally different significance. For instance, the computer was programmed to make lichenoid purpura a specific diagnosis, while the dermatologist simply indicated chronic pigmented purpura. The Stevens-Johnson syndrome, a specific, pluriorificial type of erythema multiforme that involves the mucous membrane including the conjunctiva, was diagnosed specifically by the computer, but the dermatologist used the more general term of erythema multiforme. Atopic dermatitis is a specific, disseminated form of lichenified, chronic eczema; contact dermatitis is another, different type, usually localized and isomorphic. Both were diagnosed specifically by the computer, but by the dermatologist simply as eczema.

Two of the six cases of similar diagnosis were nodular. One of these was conglobate acne, a severe, cystic, extensive, chronic form of acne. The computer was programmed to regard conglobate acne as a specific disease, as it is rare, progressive, and occurs almost exclusively in men. The dermatologist's diagnosis was cystic acne.

In one case of ulcerated nodules, both the computer and the dermatologist correctly considered the diagnosis of deep fungus infection. The dermatologist did not go further. CLINDERM showed the diagnosis of blastomycosis, with a differential list of specific fungus diseases.

In 31 cases the computer and the dermatologist each made a differential diagnosis that included one or more common diagnoses. In Table 3 the first column shows the

definitive diagnosis that the computer was programmed to give. The second column shows the common terms in the differential diagnosis suggested by the computer and by the dermatologist. The five nodular presentations in this category of common differential diagnosis comprised ganglion, multicentric reticulohistiocytosis, sebaceous hyperplasia, verruca vulgaris, and xanthogranuloma.

In six instances the computer and the dermatologist made a different diagnosis on the same case (Table 4). In one case "silvery scaling" in the description of ichthyosis inadvertently suggested psoriasis to the dermatologist. The word "cellulitis" in a description led to a diagnosis of cellulitis by the dermatologist, for ulcerative, nodular, indurated lesions. The computer listed cryptococcosis and other deep fungus infections. In another case the dermatologist could not make a diagnosis based on the computer's description. The lesions were described as nodular, circumscribed, solid, indurated; superficial; nonulcerative; smooth, rounded, firm, discolored elevations. From this description, the computer was programmed to make the diagnosis of sarcoidosis, with up to 10 other diagnoses in the differential diagnosis.

Four of these 6 lesions, different or incapable of diagnosis, were nodular. The two other multiple nodular presentations in this group were connective tissue nevus and subcutaneous fat necrosis of the newborn.

DISCUSSION

The question addressed in this work was whether the partly subjective practice of dermatological diagnosis can be converted into an objective analytic procedure, using a computer programmed with an extensive knowledge base of specific features in sets of standardized criteria.

The CLINDERM system has been tested at two betasites by other qualified dermatologists and is believed to be free of logical errors. The software is available commercially, but until now has been offered only to dermatologists who have actually operated it at national and international meetings. The senior author has a financial interest in the product, which is already in use at a United States Veterans Administration hospital and by several dermatologists in this country and in Europe.

The algorithmic system of classification is based largely on Darier's classic text,[2] modified to eliminate the dated emphasis on syphilis, tuberculosis, glanders, and other infections then much more common but now rare. The numerous diseases involving the skin that have been delineated since Darier's time have been added to the knowledge base.

The main difference between Darier's categorization and that of CLINDERM is that the latter's categorization

TABLE 3. COMPUTER- AND DERMATOLOGIST-DETERMINED COMMON DIFFERENTIAL DIAGNOSIS

Definitive Diagnosis	Common Differential Diagnosis
Argyria	Addison's disease Argyria Ochronosis Hemochromatosis
Atopic dermatitis	Lichen simplex chronicus
Bullous drug eruption	Erythema multiforme Bullous drug eruption
Dermatophytosis	Psoriasis Eczema
Drug eruption	Drug eruption Toxic epidermal necrolysis Viral exanthem
Dysplastic nevus	Lentigo Dysplastic nevi
Erysipelas	Sweet's syndrome Erythema multiforme
Erythema induratum	Pyoderma gangrenosum Stasis ulcer
Factitial dermatitis	Burn
Ganglion	Paronychia
Grover's disease	Grover's disease
Junction nevus	Lentigo Junction nevus
Larva migrans	Erythema ab igne
Multicentric reticulohistiocytosis	Rheumatoid nodule Multicentric reticulohistiocytosis
Mycosis fungoides	Mycosis fungoides
Nevus cell nevus	Seborrheic keratosis Nevus
Onychomycosis	Psoriasis Onychomycosis
Pyoderma gangrenosum	Deep fungus infection Pyoderma gangrenosum Tuberculosis Syphilis
Rubella	Viral exanthem Kawasaki syndrome Infectious mononucleosis
Scabies	Scabies
Scleromyxedema	Morphea, disseminated

TABLE 3. (*CONTINUED*)

Definitive Diagnosis	Common Differential Diagnosis
Sebaceous hyperplasia	Xanthelasma
Steroid-induced purpura	Traumatic purpura Senile purpura
Sweet's syndrome	Erysipelas Sweet's syndrome
Tinea capitis	Alopecia areata Tinea capitis
Toxic epidermal necrolysis	Toxic epidermal necrolysis Drug eruption
Trichotillomania	Alopecia areata Tinea capitis Trichotillomania
Verruca vulgaris	Verruca
Verruca vulgaris (of nail fold)	Paronychia
Xanthogranuloma	Xanthoma
Xanthoma disseminatum	Morphea

begins with the primary lesion, whereas Darier opens directly with the morphology of the eruption. Other apparent idiosyncracies have been avoided, such as Darier's consideration of atrophy and sclerosis together.

Some of the authorities mentioned in the references have used algorithms for parts of their subject, but in the CLINDERM classification the entire domain of dermatology can be visualized as a tree structure. The classification cannot be depicted explicitly on paper, however, because of physical limitations, as the number of branches increases exponentially, which is the reason for its adaptation to computer memory.

To avoid problems of idiosyncratic terminology, each use of a specialized dermatologic term is followed in the description, where space permits, by a more general synonymous phrase or definition (Figures 3 to 6). As a result, another version with different terminology should not be needed for use by family physicians.

A similar conceptual approach with a different knowledge base has been previously employed for histopathology, in TEGUMENT, a computer-assisted dermatopathologic diagnosis system. An article on this subject has already been published.[1]

The object of the study reported here was to validate that the knowledge programmed into the computer in the form of objective description leading to diagnosis of each case can give rise to a similar diagnosis in the mind of an academic dermatologist. The diagnostic criteria were purely clinical and morphologic.

TABLE 4. DIFFERENT DIAGNOSES OF SAME CASE MADE BY COMPUTER AND DERMATOLOGIST

Computer	Dermatologist
Connective tissue nevus Nevocytic nevus Fox-Fordyce disease Basal cell nevus syndrome Lichen amyloidosus Lichen myxedematosus Cowden's syndrome Perforating folliculitis Kyrle's disease	Syringoma Epidermal nevus Darier's disease Sarcoid
Cryptococcosis Atypical mycobacterial infection Sporotrichosis Blastomycosis Leishmaniasis Actinomycosis Chromomycosis Mycetoma Lepromatous leprosy Scrofuloderma	Cellulitis Panniculitis Pyoderma gangrenosum Vasculitis
Drug eruption Collagen vascular disease Scarlet fever Measles	Erythroderma Toxic epidermal necrolysis
Ichthyosis vulgaris Asteatosis	Psoriasis Pityriasis lichenoiodes chronica
Sarcoidosis Seborrheic keratosis Verruca vulgaris Nevocytic nevus Granuloma annulare Keloid Atypical mycobacterial infection Keratoacanthoma Tuberculoid leprosy	(Did not make a diagnosis)
Subcutaneous fat necrosis of newborn	Juvenile xanthogranuloma
Connective tissue nevus Generalized eruptive histiocytosis Hunter-Hurler syndrome Lipid proteinosis	Urticaria pigmentosa

The patients were not followed up for the purposes of the study, as the object was to compare the computer's and dermatologist's diagnoses with each other directly, rather than with laboratory tests or subsequent developments. For instance, direct microscopic examination of scales in potassium hydroxide solution is indicated in dermatophytosis. Such cases were included in the study, however, as these diseases have to be considered in the differential diagnosis before the test is made.

When the diagnoses were not in agreement, the computer knowledge base had to be modified to remove inadequate, ambiguous, or inadvertently tendentious descriptive terms. In these cases the dermatologist's diagnosis was added to the differential diagnosis in the computer memory.

In similar diagnoses of marginally different significance, the dermatologist did not always distinguish between two related diagnoses in which one is a variant of the other. The computer was programmed to interpret every description with a specific diagnosis, while the dermatologist tended to make more general diagnoses.

Some terms are not completely standardized, for instance, eczema and dermatitis. These terms are almost synonymous, the difference between them being similar to the variance between the concepts of pneumonia and pneumonitis. Some other terms could perhaps be superannuated, but they are still useful to describe specific cutaneous findings. Many dermatological diagnoses are descriptive, but as such they may be preferable to eponyms, which are not even descriptive.

The computer and the dermatologist frequently considered equivalent diagnostic terms in the differential diagnosis because less information is needed to make such a list than to arrive at a definitive diagnosis. The computer operator, however, has an advantage over the dermatologist of seeing on the computer screen a list of all distinguishing features that characterize closely related diseases.

The computer and dermatologist made a different diagnosis in several cases because some descriptive terms were imperfect, equivocal, inadvertently misleading, or prejudicial of a particular diagnosis in the dermatologist's mind.

Several nodular lesions were diagnosed correctly by both dermatologist and machine, but they represent a small minority of the total. Including the description that was inadequate for diagnosis by the academician, a majority of the different diagnoses were nodular presentations. The morphological description of a nodule often cannot be made sufficiently specific for a single, definitive clinical diagnosis.

The nodular eruption of which the dermatologist was unable to make a diagnosis lacked the certain critical minimum of information required for an objective diagnosis; this case is an example of an eruption of which an objective description is capable of more than one interpretation. Such diseases can hardly be distinguished definitively by their clinical or gross morphology. A diagnosis and differential diagnosis consistent with multiple nodular lesions can be listed. In all such cases, however, biopsy is indicated.

A drug-induced reaction can simulate almost any other eruption.[12] For this reason, the description of a drug eruption by the computer suggested a number of specific diseases to the dermatologist.

The knowledge base was continually upgraded by information from this iteration. Actions were taken to improve the agreement between machine and human by making the descriptions more specific. The chief modifications required in the knowledge base were to avoid nonspecific, vague, or biased descriptive terms and to add the dermatologist's diagnoses.

A factor limiting the diagnostic accuracy of the system is the ability of the operator to translate morphologic features into the objective form expected by the computer. A certain amount of skill is required in recognizing morphology. Most physicians are already trained to some extent in this subject, however, and the computer prompts with lists of observations to be searched for in the patients being examined.

This process actually represents human-aided computer diagnosis. The programmed computer may be regarded as an electronic textbook, and even in the absence of a patient, it can provide explanation and teaching. Any number of possible variations of theoretical morphologic description will each lead to a differential and a definitive diagnosis. The system may therefore find another use in continuing education.

CONCLUSIONS

Eruptive and noneruptive diseases of the skin can usually be diagnosed from their morphology or from an objective description. Accordingly, a computer can be programmed to list differential and definitive diagnosis according to specific morphologic description.

Most lesions that are not diagnosable on inspection of the gross morphology are nodular. Lengthy lists of differential diagnosis of nodules can be given, but biopsy and histopathologic interpretation are required for definitive diagnosis of such lesions.

In this study the computer and the dermatologist both considered equivalent terms in the differential diagnosis of a number of cases because less information is needed to list possible diagnoses than to arrive at a definitive diagnosis. The computer made more definitive diagnoses because it was programmed to make a specific diagnosis from every different description.

The program provides the physician with the advantage of seeing on the computer screen a list of all characteristic features that distinguish closely related diseases.

The following reasons accounted for the variance in diagnosis:

1. Some descriptive terms are insufficient, ambiguous, inadvertently tendentious, or prejudicial of certain diagnoses.

2. Standardization of diagnostic terms is less than complete.

3. Certain diagnoses represent variants of other diseases.

4. Drug-induced reactions can simulate many other eruptions.

References

1. Potter B, Ronan SG: Computerized dermatopathologic diagnosis. J Am Acad Dermatol 1987; 17:119–131
2. Darier J: Textbook of Dermatology. Philadelphia & New York, Lea & Febiger, 1920
3. Fitzpatrick TB, Walker SA: Dermatologic Differential Diagnosis. Chicago, Year Book Medical, 1962
4. Lazarus GS, Goldsmith LA, Tharp MD: Diagnosis of Skin Disease. Philadelphia, FA Davis, 1980
5. Tharp MD, Charley MR, Gilliam JN: An analytic approach to the diagnosis of skin diseases. In Stein JH (ed): Internal Medicine. Boston, Little, Brown, 1983, pp 999–1012
6. Kraus SJ: Evaluation and management of acute genital ulcers in sexually active patients. Urol Clin North Am 1984; 11:155–162
7. Lamberg SI: Dermatology in Primary Care. Philadelphia, WB Saunders, 1986
8. Lynch PJ: Dermatology for the House Officer, ed 2. Baltimore, Williams & Wilkins, 1987, pp 67–78
9. Stoecker WV: Computer-aided diagnosis of dermatologic disorders. Dermatol Clin 1986; 4:607–625
10. Vanker AD, Stoecker WV: AI/DERM: Diagnosis of skin tumors. Proceedings of the AAMSI Congress. Washington, DC, American Association for Medical Systems and Informatics, 1984, pp 213–217
11. Presser SE, Taylor JR: Clinical diagnostic accuracy of basal cell carcinoma. J Am Acad Dermatol 1987; 16:988–990
12. Bruinsma W: A Guide to Drug Eruptions: A File of Side Effects to the Skin, ed 4. Oosthuizen, Netherlands, De Zwaluw: Norwood, NJ, American Overseas Book Co (distributor), 1987, pp 115–122