THE ROLE OF INSTRUMENTAL DIAGNOSTIC METHODS IN THE STAGING OF SUDECK'S DISEASE

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Forty patients with Sudeck's atrophy were assessed in order to evaluate the diagnostic accuracy of xray, scintigraphy and telethermography in staging the 3 phases of the disease. The dynamic and early static phases of scintigraphy were the most sensitive and specific instrumental tests for detecting the early stage, whereas telethermography was fairly sensitive but not very specific. Radiographic examination was not sensitive in detecting slight changes in bone density, but it was the most reliable index for recognizing the transition to stage II of the disease. Moreover, it was possible to confirm that the late static phase of scintigraphy is the index which is best related to bone metabolism.

Keywords : Südeck's disease ; diagnosis ; scintigraphy.
Mots-clés : maladie de Südeck ; diagnostic ; scintigraphie.

INTRODUCTION

Sudeck's atrophy (SA) is a reflex sympathetic dystrophy which involves a skeletal segment, the surrounding soft tissues and the skin. This disease often has a posttraumatic etiology but the location and the importance of symptoms are often not related to the injury. Less frequently it arises in neurotic subjects in the absence of trauma and has frequent relapses. The few contributions to the knowledge of the pathological aspects of S.A. were made by chance during autopsy on amputated stumps and rare biopsies. The classical studies by Sudeck (17), Rieder (14), Reme (13), Landoff (8, 9) and Rutischauser (16) give evidence of 3 evolving histopathological stages : I) hyperemia and osteoclastic resorption, II) bone atrophy with uneven bone formation, vascular stasis and disappearance of the fatty marrow, III) disappearance of vascular changes and new bone formation with normal and/or a gross trabecular pattern.

A three-phase development may be recognized in the clinical course as well, with typical symptoms in each phase. In stage I symptoms have a local inflammatory picture : severe pain, tenderness, swelling, hyperthermia and flushed skin. X ray analysis is rarely able to show any evidence of osteoporosis, except for those cases in which bone resorption activity is high and, consequently, bone loss is rapid. Microvascular changes (active and passive hyperemia) occur in this period. Stage I lasts 4 to 6 weeks. In stage II inflammatory symptoms disappear and dystrophic symptoms arise : i.e. the skin is cold, thin and dry and the joint is rather stiff. The main characteristic of this stage is the radiological detection of "spotty" osteoporosis. In stage III the patient may completely recover from the illness or undergo irreversible dystrophic injuries. Moreover, osteoporosis may either disappear or result in gross bone rarefaction.

In spite of the peculiarity of the clinical pattern of SA, there are some diagnostic difficulties, because it is necessary to recognize not only the disease but also its stage in order to employ a coherent therapy. Therefore, the accuracy of diagnostic methods in detecting the features of each

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stage and the possibility of relating instrumental data to each clinical phase are of utmost importance.

The aim of this study is to assess the role and the accuracy of routine blood and urine tests, xray (XR), telethermography (TTG) and three-phase scintigraphy (TPS) in recognizing the stage of the disease.

MATERIALS AND METHODS

This study was performed on 40 patients (25 males and 15 females, mean age = 34.5 ± 8.3 years) with SA arising after trauma to a limb. Diagnosis was made on the basis of clinical criteria. All patients underwent the following instrumental examinations : XR, TTG and TPS. Moreover, a blood sample after overnight fasting and a 24-hr urine sample were obtained from each patient in order to evaluate the following parameters : plasma and urinary calcium, plasma and urinary phosphate, ESR (I.K.), alkaline phosphatase and urinary hydroxyproline. Both instrumental examinations and laboratory tests were performed immediately after the onset of symptoms. The TPS and TTG were repeated after 6 and 12 months, XR and laboratory tests after 1, 3, 6 and 12 months.

Radiographic findings were subjectively assessed by comparing the standard xrays of the healthy and the affected limb. If a difference in optical bone density did exist the result was considered positive.

Thermographic evaluations were performed using an AGA 680 Thermovision apparatus, and the images of both the healthy and the affected limb were recorded on Polaroid color film. Before thermography each patient spent 20 minutes in a room at a temperature of about 20-22°C. The result was considered positive when a difference in temperature of at least 2°C between the two limbs was measured.

Scintigraphy was performed by administering a bolus of 20 mCi (740 mEq) of Tc^{99m}-methylene-diphosphonate through either the median cubital vein or the femoral vein. A large field of view scanner (LFOV) with a high sensitivity parallel holes collimator (HPS) was employed. The scanner was linked with an analogic sequential photo-recorder and a microcomputer (Philips PDS 11). Both analog and digital records were taken. Dynamic sequential images (Dynamic Phase Scans : DS) were obtained one every 5 seconds for the first 60 seconds, followed by 40 images, one every 15 seconds. After dynamic recording (12 minutes) a blood-pool image (Early Static Phase Scan : ESS) was taken without varying the region of interest. After two hours with adequate hydration (almost 1 l water), the patient underwent a late static bone scan (Late Static Phase Scan : LSS). The assessment of scintigraphic results was made as previously described (5) by comparing the affected and the contralateral limb, both in a subjective way by reading the analog images and objectively by computer processing of time activity curves taken from the analysis of the regions of interest (ROI) selected from symmetric areas of the healthy and the affected limbs. Scintigrams were reviewed by all authors at a joint session. "Positive" static scintigrams were defined as those showing increased activity of the affected limb. Abnormal uptake in a localized area was considered "negative" unless associated with the more diffuse, typical pattern of SA. Radionuclide flow studies were read as "positive" when there was asymmetrical blood flow in the limbs.

RESULTS

Laboratory tests (table)

In our series there were no relevant changes in plasma calcium (average = 8.83 mg/100 ml), phosphate levels (3.75 mg/100 ml) or sedimentation rate (I.K. = 21.5) during the course of the disease. Alkaline phosphatase (46.5 mU/ml), urinary calcium (0.33 g/24 h), phosphate (0,72 g/24 h) and hydroxyproline (35.5 mg/24 h) were around the upper limit of the normal range. We observed an increase in these parameters only in the first tests, and no changes were subsequently detected. Moreover, we did not observe an increase in urinary hydroxyproline beyond the normal limits as reported by other authors (2).

Xrays (figs. 5, 6 and 10)

In patients observed in the early stage of the disease xrays revealed no decrease in bone mineral content. Positive radiological aspects could be recognized in the second xray (after 1 month) ; at this time 9 patients (22.5%) showed radiographic evidence of bone mineral content loss. The percentage of positive findings increased in the subsequent follow-up examinations ; osteoporosis was seen in 26 cases after 3 months (fig. 5) and in 33

Table. — Trend of the mean values of biochemical tests (P = plasma ; U = urinary : d = day). All values are referred to 100 ml unless otherwise specified.

		1 month	3 months	6 months	1 year
Ca^{++}	P	8.99 ± 0.8 mg	8.87 ± 0.5 mg	8.66 ± 0.5 mg	8.81 ± 0.6 mg
HPO_4^{--}	P	3.96 ± 0.5 mg	3.65 ± 0.5 mg	3.72 ± 0.4 mg	3.67 ± 0.4 mg
Al.Ph.	P	48 ± 8 mU/ml	51 ± 9 mU/ml	45 ± 7 mU/ml	42 ± 6 mU/ml
E.S.R.	P	I.K. 32 ± 8	I.K. 27 ± 5	I.K. 16 ± 6	I.K. 11 ± 3
Ca^{++}	U	0.39 ± 0.1 g/d	0.42 ± 0.1 g/d	0.29 ± 0.1 g/d	0.20 ± 0.1 g/d
HPO_4^{--}	U	0.89 ± 0.2 g/d	0.75 ± 0.2 g/d	0.69 ± 0.1 g/d	0.55 ± 0.1 g/d
Oh-Prol.	U	49 ± 3 mg/d	40 ± 2 mg/d	31 ± 2 mg/d	22 ± 2 mg/d

after 6 months (fig. 6). At the end of the study (1 year) the radiographic signs of osteoporosis were present in 85% of patients (34) (fig. 10).

Telethermography (figs. 4 and 7)

At the beginning of the study the TTG showed hyperthermia of the affected limb (difference in temperature greater than 2°C) in 37 patients (fig. 4), whereas after 6 months the temperature of the affected limb was close to or lower than that of the healthy one. In the late TTG there was almost no difference between the two sides (fig. 7).

Three-phase scintigraphy (figs. 1, 2, 3, 8, 9a and 9b)

— *Dynamic Scans (DS).* We observed an increase in local blood flow of the affected limb as compared with the contralateral one. This difference was evident in 36 patients (90%) at the first scintigraphy (fig. 1), and the time activity curves of selected Roi's allowed quantification of the observed phenomena (fig. 2). After 6 months 4 patients (10%) had a slightly increased blood flow, but this was most frequently normal (65%) or decreased (25%). At the third examination (1 year) the recorded flow was almost always normal, and a lower uptake in the affected limb was observed in 4 cases.

— *Early Static Scans (ESS).* At the beginning of the study there was a highly increased uptake in 35 cases (87.5%) (fig. 3) and a normal uptake in 5 (12.5%). Tests after 6 months showed an increased uptake in 6 patients (15%), and a lower uptake in 14 (35%). No difference was observed between the two sides in 20 patients (50%). During the late examination normal results were observed in 37 cases (92.5%) (figs. 8, 9a and 9b) and a decreased uptake in 3.

— *Late Static Scans (LSS).* This phase of scintigraphy showed positive images of the affected side in 12 patients (30%) at the first examination. In 4 (10%) cases the uptake was normal and in 24 (60%) lower. After 6 months there was constant unilateral hyperactivity in the affected side, which was still present in 27,5% of cases after 12 months.

DISCUSSION

The diagnostic and prognostic accuracy of the instrumental and biochemical tests in SA has been assessed by many authors in the past. Kozin and co-workers (6) compared the accuracy of TPS with that of XR. By studying a group of 64 patients, they found a slightly better sensitivity of XR (67% vs. 60%), but a higher specificity of TPS (92% vs. 73%). Mackinnon and Holder (10), in 145 consecutive patients with reflex sympathetic dystrophy of the hand, observed 98% sensitivity of the late static phase, whereas the dynamic and early static phase were respectively positive in only

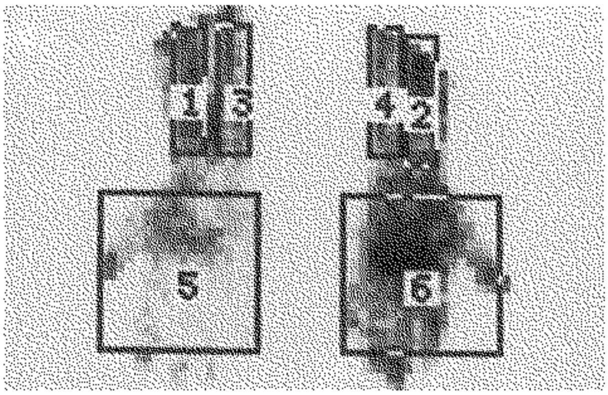

Fig. 1. — Colles' fracture 2 months after trauma. Three-phase scintigraphy (first examination) : dynamic scan with ROI shows the increase in local blood flow of the affected limb (on the right) compared with the contralateral limb.

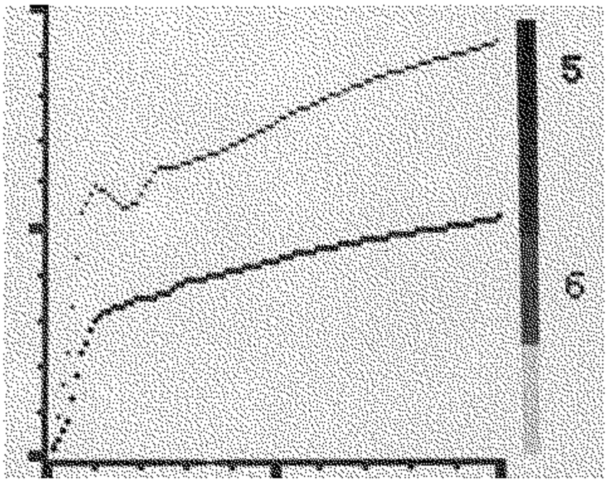

Fig. 2. — Colles' fracture 2 months after trauma. Three-phase scintigraphy (first examination) : the time-activity curves of selected regions of interest (ROI) allow quantification of the different uptake levels, i.e. the difference in local blood flow, between the healthy and the affected limbs.

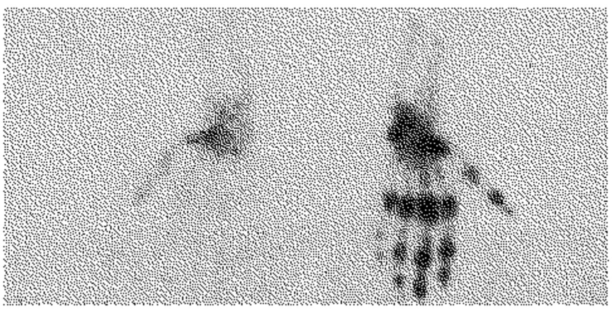

Fig. 3. — Colles' fracture 2 months after trauma. Three-phase scintigraphy (first examination) : early static scan allows the areas of bone characterized by early metabolic changes to be recognized.

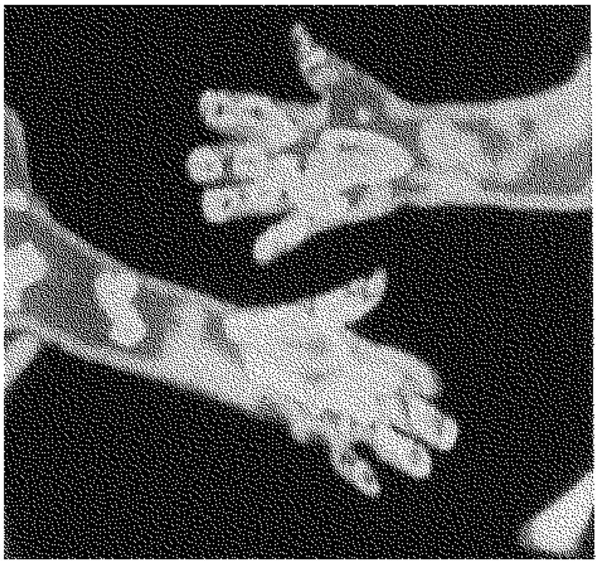

Fig. 4. — Colles' fracture 2 months after trauma. Telethermography (first examination) shows hyperthermia of the affected limb (difference in temperature more than 2° C).

Fig. 5. — Colles' fracture 5 months after trauma. In patients observed in stage I there are no radiological signs of SA. Positive xrays may be recognized subsequently (second examination) by the appearance of bone mass loss when the mineral content decreases by about 30%.

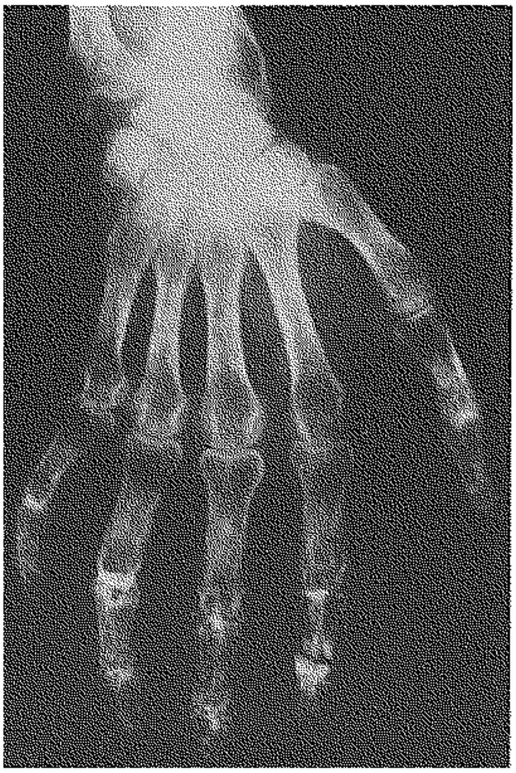

Fig. 6. — Colles' fracture 8 months after trauma. Xray examination (third examination) shows the high degree of distal bone atrophy.

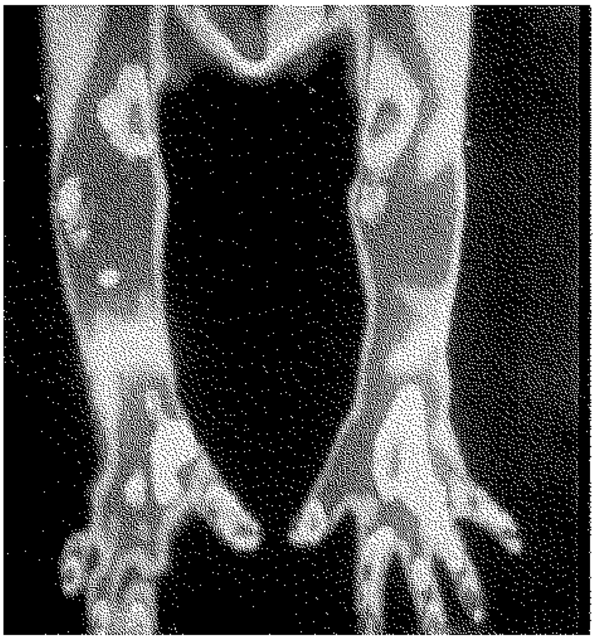

Fig. 7. — Colles' fracture 14 months after trauma. Telethermography (last examination) does not show a significant difference between the two sides.

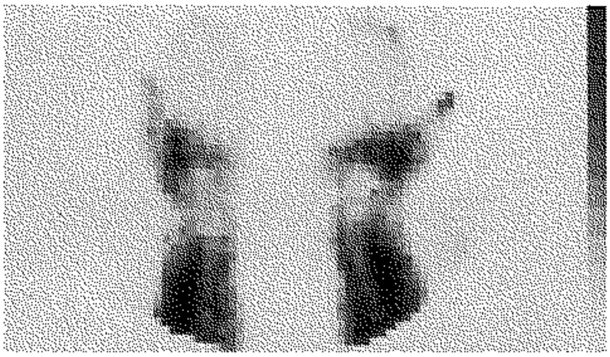

Fig. 8. — Colles' fracture 14 months after trauma. Three-phase scintigraphy (last examination) : early static scan does not allow recognition of any difference in blood flow between the two sides.

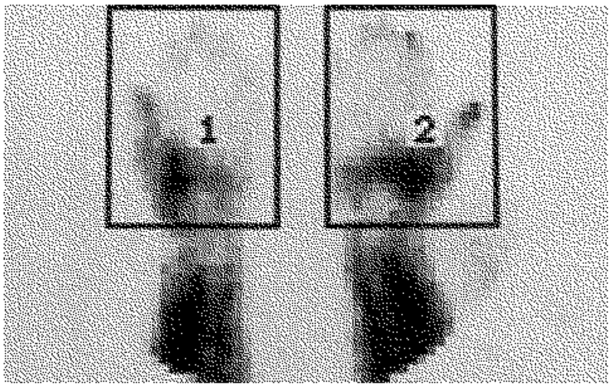

Fig. 9a

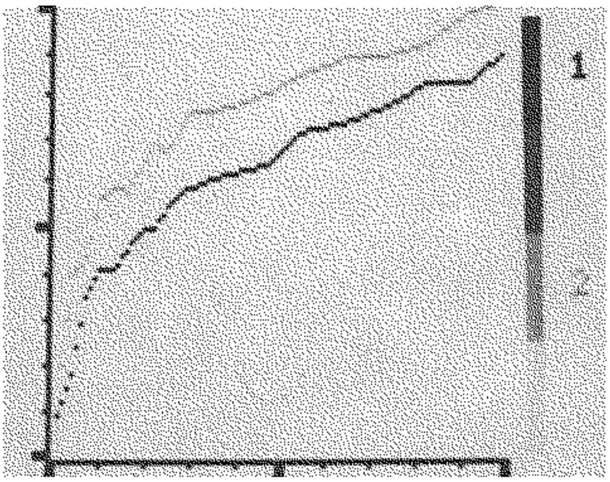

Fig. 9b

Fig. 9a-b. — Colles' fracture 14 months after trauma. Three-phase scintigraphy (last examination) : the time activity curves (b) of ROI (a) do not permit detection of any significant difference in local blood flow between the healthy and affected limbs.

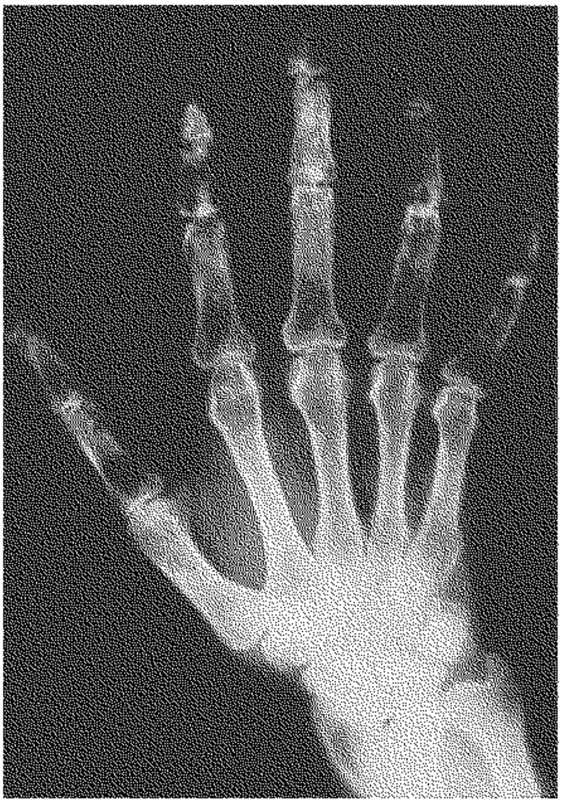

Fig. 10. — Colles' fracture, 14 months after trauma. Xray (last examination) shows the slow recovery of the normal bone mass. Atrophy persists above all in the phalanges.

45% and 52% of the patients. These studies assessed the diagnostic reliability of each technique without considering the different stages of the disease.

In view of the pathophysiological and clinical characteristics of each stage of the disease, we tried to evaluate both the role and the usefulness of diagnostic instrumental tests in detecting the features of each stage and to relate the instrumental data to each clinical phase. Therefore, we analyzed all the results on the basis of chronological criteria, i.e. the time elapsed since the onset of symptoms. This does not always strictly correspond to the specific stages of SA in the different patients but may be considered roughly representative especially during the early phase of the disease. Moreover, unlike other studies (3, 6, 8, 12), our series included only the posttraumatic variant of SA and no cases with a different etiology (such as a neurological etiology).

It has been emphasized that in the early phase of SA the vascular changes are more important. In our study, the sequential dynamic phase of TPS shows an increased local blood flow in the affected side compared with the healthy one. An increase in blood flow was detectable in the early stage and was specifically related to the presence of the disease (6), whereas in the late controls the time activity curves of selected zones had the same pattern in the two limbs.

Kozin and co-workers (6) reported an asymmetric increased blood flow in the affected limb only in patients with vasomotor instability or swelling, which are, according to us, typical symptoms of the early phase.

The ESS-images are strongly positive when examination is carried out in the early stage of the disease. This phenomenon is now explained as an index of the increase in the vascularity of surrounding soft tissues (increase in blood pool due to vascular stasis and increase in interstitial fluids due to edema) (5, 6, 11). In the subsequent follow-up examinations there is a variable pattern of ESS-images, but a normal or lower uptake is most frequently decreased because of a decrease in blood flow.

The LSS images reflect the metabolic activity of bone (5, 6, 11). The ESS images show a major incidence (70%) of normal or increased uptake, as compared to the contralateral limb. Uptake levels can however be considered truly normal or decreased when they are read over the total increase of blood flow in the affected limb, as reported in previous studies (6, 10). Only in the later stages of SA when the blood flow reaches the same value in both limbs may the increase in bone uptake be related to a real change in bone turnover rather than in blood flow (10).

The LSS image can detect activity of the lesion for a longer time than dynamic and ESS images ; this may account for previous reports which emphasized a higher diagnostic sensitivity of LSS than of DS and/or ESS (10). The latter, on the other hand, is more specific and reliable for early diagnosis of the disease, as our own observations confirm.

Previous studies highlighted the low sensitivity and specificity of xray. Rosen and Graham (15) and Arnstein (1) reported radiographic positivity in algodystrophy in 30% and 62% of patients, respectively, and Kozin and co-workers (6) found a sensitivity of about 67%. In our series XR is almost always negative in the early stage of the disease. We never observed mineral loss before the second examination (first month). The low sensitivity results from an intrinsic deficiency of the method. Changes in bone density can be detected if they are as much as about 1/3 of the original bone density (7) ; in SA this decrease rarely occurs before 1 month.

The finding that the number of positive patients increases in the subsequent follow-up examinations led us to conclude that the sensitivity of XR depends on the stage of the disease. Kozin and co-workers (6) did not find a relationship between the duration of symptoms and the presence of osteoporosis because only 58% of patients with a longer duration of symptoms than one year had radiographic osteoporosis. This observation is based on results that are not easy to compare with ours for the following reasons : 1) our results refer to a 1-year period ; 2) our examined population included only cases of posttraumatic algodystrophy. Moreover, Kozin and coworkers (6) showed that early osteoporosis (within 4 to 8 weeks) appeared in patients with more evident symptoms of algodystrophy (Groups I, II, III of their series).

Our findings agree with those of other authors (3, 7) in defining "spotty" osteoporosis as nonspecific, particularly in the differential diagnosis with disuse osteoporosis. For this reason, radiographic findings of SA cannot be considered pathognomonic. Therefore, XR is not the most suitable test for an exact and early diagnosis of SA, even if it may be helpful in association with the other investigations. Otherwise, the radiographic evidence of changes in bone density might be considered a reliable hallmark of stage II SA.

TTG is an extremely nonspecific investigation technique because the detected thermic changes may be the consequence of inflammatory, neoplastic or degenerative pathologies. In the past we studied this method to evaluate the efficacy of therapy with calcitonin in Paget's disease (4), and we emphasized that it is not suitable for the solution of the subtle problems regarding differential diagnosis. TTG, rather, is a simple, noninvasive and economic method for following the development of an already known pathology. Its indications and limits are also valid for SA, in which, moreover, our results show a good correlation with the staging of the disease ; TTG is intensely positive in the early stage, but it is not able to detect appreciable thermic differences between the affected and the contralateral limb during the following stages.

The assessment of our results allows us to conclude that in each stage of SA there is a characteristic pattern of the instrumental findings. In stage I TPS shows the vascular changes of SA : the dynamic study detects the increase in the local blood flow, ESS confirms the enlarged local blood pool, and the LSS of the affected side shows a relatively higher uptake than the control side. TTG highlights the local thermic increase. XR is almost always negative. Laboratory indexes show a slight increase. In stage II the dynamic phase of TPS shows a normal or decreased blood flow and the ESS has a normal or low uptake, whereas the uptake is increased in LSS. The characteristic feature of this period may be the appearance of radiographic signs of osteoporosis. Even if the XR pattern is not specific, this bone loss might be a hallmark of stage II. TTG reveals a skin temperature equal to or lower than the normal side. There is no change in hematologic and urinary parameters of phosphocalcium metabolism. The transition to stage III is gradual, there being no particular instrumental findings. In the long run TPS becomes negative, but as in to Kozin's reports (6), we observed a higher uptake in the affected limb up to the last follow-up visit (1 year). The XR shows the regression of bone atrophy which may either completely disappear or give bone rarefaction with a gross trabecular pattern. TTG does not show any marked difference between the two sides.

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SAMENVATTING

F. GRECO, L. DE PALMA, N. SPECCHIA, M. MANNARINI, A. GIGANTE. Instrumentale diagnostische technieken bij de stadium evaluatie van reflex sympatische dystrofie van Südeck.

Bij 40 patiënten met een reflex sympatische dystrofie (RSD) werd de diagnostische betrouwbaarheid van het rö-onderzoek, van de scintigrafie en van de telethermografie bij de bepaling van de 3 stadia van de ziekte onderzocht. De dynamische en de vroegtijdige statische fasen van de scintigrafie waren het meest gevoelig en specifiek bij de diagnosestelling van het vroegstadium. De telethermografie was relatief gevoelig, maar niet bijzonder specifiek. Het rö-onderzoek was niet gevoelig om lichte wijzigingen in de botdensiteit te diagnosticeren, maar was de meest betrouwbare index bij de vaststelling van de evolutie naar het stadium II. Bovendien kon bevestigd worden dat het botmetabolisme het best gedocumenteerd wordt door de late statische fase van scintigrafie.

RÉSUMÉ

F. GRECO, L. DE PALMA, N. SPECCHIA, M. MANNARINI, A. GIGANTE. Importance des techniques diagnostiques instrumentales dans l'évolution de la maladie de Südeck.

Chez 40 patients, présentant une algodystrophie de Südeck, la valeur diagnostique de la radiographie, de la scintigraphie, et de la téléthermographie fut évaluée au cours des 3 phases de la maladie. Les phases dynamiques et statiques précoces de la scintigraphie étaient plus sensibles et plus spécifiques dans la détection du stade précoce, alors que la téléthermographie était relativement sensible mais peu spécifique. L'examen radiographique n'est pas contributif pour la détection de légères variations de la densité osseuse, mais il se révéla le plus fiable pour établir la transition vers le stade II. D'autre part, les auteurs ont pu confirmer que la phase statique tardive de la scintigraphie documente le mieux le métabolisme osseux.