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Assessment of inflammation in the rheumatoid knee joint: correlation between clinical, radioisotopic, and thermographic methods

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SUMMARY Standard clinical methods of assessing joint inflammation are being supplemented increasingly by radioisotopic and thermographic studies. However, the correlation between these different methods has not been firmly established. In the quantification of synovitis by infrared thermography we have shown that the heat distribution index (HDI) based on thermal pattern is more reliable and is less affected by diurnal variations in joint temperature than the commonly used thermographic index, which is based on average skin temperature values. In 20 patients with rheumatoid arthritis whose knees were being treated with intra-articular steroid we obtained 184 serial paired observations over a period of 24 weeks for clinical assessment, HDI, and ^{99m}Tc pertechnetate uptake. We found significant correlations ($p<0{\cdot}001$) between the three methods of assessment (except for pain and HDI ($p=0{\cdot}116$)).

Key words: rheumatoid arthritis, treatment, disease activity.

There is a need for objective, reproducible, relevant, and accurate methods of assessing inflammatory joint disease. Many parameters are based on patients' symptoms, which may not give an accurate indication of the progress of the disease,[1] and laboratory evaluation may be unhelpful. The number of indices of disease activity available testify to the absence of any single acceptable parameter. This is partly because of the complex nature of rheumatoid disease but also reflects the subjective nature of most of the indices. Absolute identification and quantification of inflamed tissue would require invasive methods, which are both impracticable and unjustifiable. However, safe, sensitive, objective, reproducible, and quantifiable methods of assessment are desirable. Radioisotopic and thermographic methods have been developed to provide such methods and complement the information obtained by clinical methods. Of the several different radioisotopic techniques that have been used, ^{99m}Tc pertechnetate uptake (Tc) as described by Dick *et al.*[2] has been used most frequently.

Thermographic equipment produces a multiple isotherm scan of a joint area, which is conveniently displayed on a colour monitor. This thermal image is usually quantified by an integrated numerical expression of the isothermal image to produce a thermographic index (TI).[3]

Recently, Salisbury *et al.* introduced a heat distribution index (HDI)[4] and showed that this correlated better with clinical assessment than the thermographic index (TI). Therefore we chose to use the HDI, which was developed in this unit for our present study. Correlations between clinical assessment and ^{99m}Tc pertechnetate uptake (Tc),[5 6] between clinical assessment and TI,[3 7] and between clinical assessment and HDI[4] have already been demonstrated. However, the relationship between radioisotopic methods and thermography has not been established.[8] The aim of this study was to examine the inter-relationship between clinical assessment, Tc, and HDI in rheumatoid patients with active synovitis of one or both knee joints.

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Patients and methods

Twenty outpatients with classical or definite RA (American Rheumatism Association criteria) were included whose disease activity was well controlled except for active synovitis in one or both knees. Their details are given in Table 1. Patients were assessed at the start of the study and at four weekly intervals thereafter according to a standard protocol. Each group of assessments was carried out at roughly the same time before 12 noon. Intra-articular injections were given at the start of the study and repeated if necessary by the same clinician using standard procedures (this will be the subject of a separate report).

CLINICAL ASSESSMENT

This consisted of the following: pain, swelling, and tenderness graded by the physician on a scale of 0–3 (0=none, 1=mild, 2=moderate, 3=severe). Morning stiffness in minutes was graded 0–3 (up to 15 minutes=0, >15 minutes but <30=1, >30 minutes but <60=2, >60 minutes=3). The sum of the numerical values for each of these parameters was used as a joint score with a range from 0 to 12).

Patients were requested to note down the time of onset of relief of symptoms, with particular reference to pain, swelling, and stiffness and the date on which they considered each of these parameters had reverted to the preinjection state.

^{99m}Tc PERTECHNETATE UPTAKE IN KNEE JOINTS

This was measured with a modification of the method described by Dick *et al.*[2] 100 μCi (4 MBq) of ^{99m}Tc pertechnetate was injected intravenously, and the ^{99m}Tc activity in the knees was measured at 15 and 20 minutes. The patient was positioned with a 2 inch scintillation counter over each knee, the end of the collimator being in line with the patellar surface. The activity measured within the field of view of each counter was expressed as a percentage of the injected dose by reference to a phantom counter with similar geometry. A correction was applied for the expected normal uptake in a patient of that height and weight. Subjects receiving pertechnetate for thyroid scans were used to establish the normal range.

Table 1 *Patient details*

Male/female	7/13
Age in years	Mean 55·6 Range 26–76
Disease duration in years	Mean 7·6 Range 2–20

THERMOGRAPHY

Thermography was carried out in a draught free room with ambient temperature controlled to 20·5±5°C and humidity 50±10%. Subjects were seated in a modified dentist's chair with their limbs exposed and a sleeveless jacket worn.

An AGA thermovision 680 medical system was used to detect infrared emission, and all thermograms were recorded in digital form on magnetic tape for subsequent analysis by a Varian 620 computer. The camera was placed parallel (vertical and horizontal planes) and at a distance of 1·2 m from knee joints. Knees were flexed at 90°C. Thermograms were recorded of the lateral aspect of the joint. In all instances recordings were made after a 15 minute equilibration period in the room. The HDI, which reflects the pattern and spread of temperature over a joint, was then calculated as previously described by Salisbury *et al.*[4] A region of interest on the thermogram is chosen to correspond to a fixed area over the joint. The analogue thermal signal from the AGA 680 M signal is digitised into 256 grey levels by an A/D converter. A count is then made of the number of picture elements (pixels) which occur at each grey level. Finally, each number is divided by the total number of picture points in the area of interest giving a relative frequency distribution (RFD). A calculation of the width of the RFD is made as ± 1 SD from the mean frequency = heat distribution index. The HDI is thus an approximation to the width of the major components of RFD curves and has been found to be a useful thermal parameter in arthritic patients.

STATISTICS

Spearman correlation coefficients were used throughout the study.

Results

For the group of 20 patients a total of 184 values were obtained for each of the variables. The group mean values and standard deviations for the assessment parameters are given in Table 2.

HEAT DISTRIBUTION INDEX VERSUS ^{99m}Tc PERTECHNETATE UPTAKE

The values for both parameters were symmetrically distributed as indicated by the mean and median values (Table 2). A correlation coefficient of 0·392 with $p=<0·001$ was obtained.

Table 2 *Results of assessment parameters*

Variables	*No*	*Mean*	*SD*	*Median*	*Min*	*Max*
^{99m}Tc	184	0·681	0·382	0·649	0·036	1·260
HDI	184	1·254	0·361	1·234	0·460	2·020
Pain	184	1·130	1·073	1·000	0	3·000
Swelling	184	1·097	1·040	1·000	0	3·000
Stiffness	184	1·005	1·005	1·000	0	3·000
Tenderness	184	1·831	0·957	1·000	0	3·000
Joint score	184	4·065	2·994	4·00	0	12·000

SD=standard deviation.

Table 3 *Correlation between technetium and clinical assessment*

Variables	*Correlation coefficients*	*p Value*
Pain	0·418	0·0001
Swelling	0·479	0·0001
Stiffness	0·414	0·0001
Tenderness	0·327	0·0001
Joint score	0·577	0·0001

Table 4 *Correlation between HDI and clinical assessment (CA)*

Variables	*HDI/CA correlation coefficients*	*p Value*
Pain	0·116	0·116 NS
Swelling	0·439	0·0001
Stiffness	0·179	0·015
Tenderness	0·224	0·002
Joint score	0·326	0·0001

CLINICAL ASSESSMENT VERSUS ^{99m}Tc PERTECHNETATE UPTAKE

The correlation coefficients and p values which were obtained are shown in Table 3.

CLINICAL ASSESSMENT VERSUS HEAT DISTRIBUTION INDEX

Table 4 gives values of HDI and clinical assessment parameters. All were significantly correlated with HDI except for pain (p=0·116).

Discussion

Assessing rheumatoid knees, we have shown a significant correlation between pertechnetate uptake and the heat distribution index, which has not previously been demonstrated. We also confirmed a correlation between pertechnetate uptake and clinical assessment, and between the heat distribution index and all components of clinical assessment except pain.

Although Dick and Grennan,[6] Haataja *et al.*,[9] and Paterson *et al.*[8] all found a correlation between pertechnetate uptake and clinical assessment, Huskisson's group did not.[10] His study was significantly different from ours in that a small number of patients (six) were assessed using several joints and three treatment options were used—placebo, an oral non-steroidal anti-inflammatory agent, or a 'drug of unknown activity'. It is easier for patients to assess a single active joint rather than several, and it has also been shown by Dick[11] that the relief of symptoms and reduction in radioisotope uptake are greater when a rheumatoid joint is treated with intra-articular steroid rather than oral agents or placebo. Another factor which may have contributed to the failure to show a correlation between pertechnetate uptake and clinical assessment in Huskisson's study was the different method used to calculate ^{99m}Tc clearance.

The radioisotope technique used by Paterson *et al.*[8] also differed from ours but gave equivalent results. They scanned the whole length of the body with collimated counters. The average counts were taken to be proportional to the total administered activity, and the peak counts for each knee were expressed in relation to this.

Reports of the relationship between thermographic index and clinical assessment have also been variable. Bacon *et al.*[3] found a good correlation between the two, but Huskisson[10] and Paterson[8] found the thermographic index of limited value because of the changes in ambient temperature, the timing of measurements in individual patients, and the need to measure intraknee temperature differences to obtain meaningful results. However, calculation of the heat distribution index overcomes many of these shortcomings. It reflects the pattern and spread of heat over a joint and correlates well with the clinical assessment of the severity of the

inflammation. The thermographic index, which reflects mean surface temperature, is less sensitive in demonstrating differences.

This study has shown a correlation between two objective methods of assessment and has confirmed correlations with clinical assessment. The correlation coefficients between Tc uptake and clinical assessment are generally better than those between HDI and clinical assessment, but thermographic assessment has the advantage of being easier to perform and no radioisotope is involved.

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References

1 Beecher H K. *Measurement of subjective responses*. Oxford: Oxford University Press, 1959.
2 Dick W C, Neufeld R R, Prentice A G, *et al*. Measurement of joint inflammation. *Ann Rheum Dis* 1970; **29:** 135–7.
3 Bacon P, Collins A J, Ring F J, Cosh J. Thermography in the assessment of inflammatory arthritis. *Clin Rheum Dis* 1976; **2:** 51–65.
4 Salisbury R S, Parr G, De Silva M, Hazleman B L, Page Thomas D P. Heat distribution over normal and abnormal joints: Thermal pattern and quantification. *Ann Rheum Dis* 1983; **42:** 494–9.
5 Oka M, Rekonen A, Ruotsi A, Kuikka J. Measurement of systemic inflammatory activity in rheumatoid arthritis by the ^{99m}Tc method. *Scand J Rheumatol* 1973; **2:** 101–7.
6 Dick W C, Grennan D M. Radioisotopes in the study of normal and inflamed joints. *Clin Rheum Dis* 1976; **2:** 67–75.
7 Ring E F J, Collins A J, Bacon P A, Cosh J A. Quantitation of thermography in arthritis using multi-isothermal analysis. II. Effect of nonsteroidal anti-inflammatory therapy on the thermographic index. *Ann Rheum Dis* 1974; **33:** 353–6.
8 Paterson J, Watson W S, Tensdale E, *et al*. Assessment of rheumatoid inflammation in the knee joint. *Ann Rheum Dis* 1978; **37:** 48–52.
9 Haataja M. Evaluation of the activity of rheumatoid arthritis. *Scand J Rheumatol* 1975; **4** (suppl): 1–54.
10 Huskisson E C, Berry H, Browett J P, Balme H W. Measurements of inflammation. II Comparison of technetium clearance and thermography with standard methods in a clinical trial. *Ann Rheum Dis* 1973; **32:** 99–102.
11 Dick W C. The use of radioisotopes in normal and diseased joints. *Semin Arthritis Rheum* 1972; **4:** 301–17.