HEBERDEN SOCIETY

CLINICAL MEETING.—At a meeting held on May 17, 1968, at Glasgow, the following papers were presented:

Lubrication of Human Joints. By P. S. WALKER, D. DOWSON, M. D. LONGFIELD, and V. WRIGHT (*Rheumatism Research Unit and Department of Mechanical Engineering, University of Leeds*).—The overall geometry of the hip joint was determined by casting techniques and the fine surface finish by means of Talysurf measurements. A reciprocating machine was constructed and used to measure the friction of joint cartilage under boundary lubrication conditions and to evaluate squeeze film times.

It was demonstrated that:

- (1) In the normal hip joint, contact is around a horse-shoe area.
- (2) The fine surface quality of cartilage is rough by engineering standards.
- (3) The cartilage surfaces in the hip are likely to be separated by squeeze films for prolonged periods under load.
- (4) By comparing squeeze film times of cartilage with rubber, it appears that the fluid between loaded cartilage surfaces becomes more viscous than the overall synovial fluid. This may well be due to the porosity of cartilage.
- (5) During walking, fluid films are set up by elastohydrodynamic action in the swing phase and during the loaded phase are maintained by squeeze film action. It is suggested that a mechanism of "fluid entrapment" operates in the lubrication mechanism of joints.
- (6) Osteoarthritic surfaces do not display such a great squeeze film as normal joint surfaces in some conditions, because of the surface quality.

Visco-elastic Properties of Some Pathological Human Synovial Fluids. By D. V. DAVIES and A. J. PALFREY (*St. Thomas's Hospital Medical School, London*).—Human synovial fluid can be obtained in quantity only from joints in which there is an effusion resulting from some pre-existing disease. Such fluids have been studied in the Wiessenberg rheogoniometer, a cone and plate viscometer in which any force normal to the platens can be measured while maintaining the geometry of the fluid filled space. The viscosities of these abnormal fluids are less than those of normal bovine fluids, and there is evidence to suggest that lower values are obtained in fluid from patients with rheumatoid arthritis than in those with osteoarthritis. Forces occur in bovine synovial fluids which tend either to separate or approximate the platens during the different phases of the period of rotation; similar forces occur in some human fluids, though they are reduced in magnitude. The phenomenon

of immediate viscosity, previously described in detail for some of the more viscous bovine fluids, is only found uncommonly in these human fluids. These two factors suggest that there may be changes in the elastic properties of the fluids as well as a reduction in their viscosity. The use of these observations as a basis for diagnostic and prognostic decisions in clinical work, together with the correlation between these changes and the biochemical changes known to occur in synovial fluid from diseased joints, was discussed.

Rheology of Synovial Fluids: Behaviour in Rheumatoid Arthritis and Some Possible Interpretations. By J. FERGUSON and J. A. BOYLE (*Department of Fibre Science, University of Strathclyde, and the Centre for Rheumatic Diseases, Glasgow*).—Much effort has recently been put into the investigation of the rheology (*i.e.* the flow behaviour) of synovial fluid, and the unique flow characteristics of synovial fluid are now being discovered. This paper described the flow characteristics of synovial fluid from osteoarthritic knee joints and compared them with those of fluid from rheumatoid arthritic joints.

Our recent work on patients suffering from osteoarthritis has shown that synovial fluid is of comparatively high viscosity, highly non-Newtonian, and extremely elastic. Moreover, it appears to exhibit a unique form of thixotropy. At low shear yield, stresses are encountered in the direction of shearing; at high shear these disappear, and large yield stresses appear in a direction normal to the direction of shear. These effects have not been described before for human joints.

A comparison with rheumatoid joint synovial fluid shows that this is of lower viscosity, more Newtonian, and non-elastic, and that the peak stresses do not appear. The viscosity, in fact, would appear to be related to the severity of the condition.

Two theories at present exist which purport to explain these phenomena. It is generally accepted that the flow behaviour is dominated by the hyaluronic acid/protein complex concentration. One theory is that in rheumatoid joints the complex exists in a degraded form. The other suggests that the molecules are not degraded but that the complex has dissociated. These theories were compared in the light of our experimental data and a third possibility was considered, namely that the effect might be largely one of dilution. The experiments to distinguish between the theories were described.

The physical chemistry of solutions which show the type of behaviour encountered in synovial fluid was discussed in detail and the applicability of this to flow behaviour of synovial fluid *in vivo* was considered.

Discussion.—PROF. J. J. R. DUTHIE (*Edinburgh*): I have always surmised that in osteoarthritis there was something wrong with the lubrication of cartilage.

DR. V. WRIGHT (*Leeds*): May I emphasize the rate of lubrication in relation to the cartilage surface and its possible aetiological importance with respect to osteoarthritis. May I ask Dr. Palfrey what his explanation was of the two different viscosities with no procedure other than aspiration? Does he regard this as due to the variation in his technique, or has he any other explanation? May I ask Dr. Ferguson how the patient assessed the knee stiffness which was said to be correlated with viscosity? Did the patient say the knee felt more stiff or that it felt more painful?

DR. PALFREY: In answer to Dr. Wright, it is not the misbehaviour of the apparatus. We have repeated these experiments on the same fluids on consecutive days and in order to represent them on the same slide we have had to separate the two curves. I am sure that the changes represented some real change in the properties of the fluid. I agree that there might be spontaneous changes of this order in the viscosity of the fluid over a period of 27 days in a diseased joint. On the other hand the fluid was aspirated on the first occasion and this may have been a cause for the change.

DR. FERGUSON: What the patient assessed was the relative stiffness of his two knees.

DR. R. E. PARTRIDGE (*Edinburgh*): I am not clear whether there is a difference between synovial fluid in osteoarthritis and in normal persons. Did you test fluids from other inflammatory diseases?

DR. FERGUSON: The consensus of opinion is that the fluid in osteoarthritis is the same as in a normal joint. In fact we were unable to test any normal joint: one only finds about 0.5 ml. of fluid in a normal joint and this wasn't enough to do the experiment.

PROF. E. G. L. BYWATERS (*Taplow*): Does Mr. Walker imply that if our joint fluid is more dilute, or more degraded or less efficient as a lubricant, then we do better for our joints to keep them moving rather than standing on them, as at a cocktail party for instance, for half an hour on end?

MR. WALKER: When an area of cartilage is loaded, it gradually becomes compressed as fluid is squeezed from the cartilage matrix. For a given specimen of cartilage we found that the squeeze film times, that is the times taken to squeeze out a protective layer of synovial fluid, were longer the greater the degree of compression of the cartilage. If load remains over much the same area of cartilage in a joint for any length of time, as would be the situation when standing, the cartilage bearing the load will become compressed so that when the joint is next set into motion, synovial fluid which will be drawn between the articulating surfaces will take a long time to squeeze out, much longer in fact than if the joint had not remained immobile. Another factor affecting the squeeze film time is the overall contact area between opposing cartilage surfaces; the greater the area, the greater the squeeze film time. In a hip joint for instance, we found that in joints tending to osteoarthritis the contact area was smaller or had narrow points.

Turning to the question of whether a defect in the cartilage or the fluid predisposes to osteoarthritis, though geometry and loading are thought to play a part, we have so far discovered no conclusive evidence. However, some work on the viscous and elastic properties of

synovial fluids reported at this Conference has shown certain differences between healthy and pathological fluids. We are using a scanning electron microscope to study the structure of the hyaluronic acid-protein complex in solution and believe that an important factor in the lubrication properties is the degree of molecular entanglement. The elasticity of the fluid is likely to be related to this inter-tangling. We have also studied the various stages of cartilage degeneration by wear, as opposed to that by underuse giving chondromalacia, and have found that the process of wear is begun when the large collagen fibre bundles along the cartilage surface become detached, loosening with them many attached smaller fibre bundles.

DR. A. G. S. HILL (*Stoke Mandeville*): We were shown some time ago a rather intriguing slide contrasting an electron micrograph of the surface of cartilage with that of an unused razor blade, and there the pits we saw this morning were not in evidence. Is there a true discrepancy here, or is it a matter of difference of scale?

DR. PALFREY: I think there is a discrepancy between our results and those of Mr. Walker and his colleagues. We have done a few experiments on fluid aspirated from the knees of patients with haemophilia. The main difference between these fluids and those which we described in our paper is that the fluid is contaminated with a large amount of blood. Using Dr. Ferguson's hypothesis, there is no doubt that the main effect is one of dilution. We found very much lower viscosities, but it was interesting that the immediate viscosities were more apparent in these fluids. This suggests to me that there is a difference between normal fluids and those from osteoarthritic joints.

Cardiorespiratory Performance in Systemic Sclerosis. By S. GODFREY, B. HIGGS, and R. BLUESTONE (*Department of Medicine, Royal Postgraduate Medical School, London*).—We have studied eleven patients with systemic sclerosis at rest and during exercise on a cycle ergometer. About half had small lungs and all had a reduced ability to transfer CO, but when corrected for lung volume this was reduced in only half the group. No patient had increased airways resistance.

Exercise tolerance was grossly reduced in all patients. In four this could be explained in terms of an increase in "physiological" dead space and venous admixture due to ventilation/perfusion imbalance. Most patients produced an excess of lactate.

There was no correlation between the clinical features of the disease and the physiological abnormalities.

Study of Muscle Involvement in Systemic Sclerosis. By J. THOMPSON, R. BLUESTONE, E. G. L. BYWATERS, J. DORLING, and M. JOHNSON (*Department of Medicine, Royal Postgraduate Medical School, London*).—To be published in full in the *Annals*.

Behçet's Syndrome with Arthritis—Diagnostic Criteria. By C. G. BARNES and R. M. MASON (*The London Hospital*).—To be published in full in the *Annals* with the subsequent discussion.