FROM THE DEPARTMENT OF EXPERIMENTAL HISTOLOGY, KAROLINSKA INSTITUTET, STOCKHOLM

THE NORMAL MORPHOLOGY OF THE JOINT FLUID

By

HJ. HOLMGREN

In contrast to the interesting and absorbing genesis, function and biochemics of the joint fluid, its normal morphology seems dry and uninteresting. Possibly a short review of our knowledge of the subject may be of value as regards the whole, and serve as background to the multifarious pathological anatomy of the joint fluid. By contrast, the normal morphology seems to have been greatly neglected, proof of which is seen in the fact that in modern textbooks in histology, the genesis, function and biochemics of the joint fluid are well dealt with, but not its morphology.

Le Gros Clark describes the joint fluid with these words: "The joint fluid is a clear, mucinous fluid, which, in normal cases, is found in minute quantity forming a thin film covering the inside of joint cartilage and joint capsule". Since the joint fluid seems in any case to be partly a dialysate from blood plasma and partly formed of the mesothelium of the synovialis, we scarcely have reason to expect any great diversity of cell flora (Fig. 1).

Since the cellular elements in the joint fluid are best studied in animals, and only in a few cases in human beings, my presentation must principally concern itself with the former investigations. I wish, however, to mention that the results obtained, from a biological point of view, are also of interest for our knowledge of the importance and the morphology of the joint fluid in the human being.

Characteristic of the normal joint fluid is its scarcity of cellular elements. The primary question is: which cells can we expect to find? They should be partly cells arising from the innermost layer of the capsule, and partly mobile cells in the connective tissue such as leukocytes of different kinds.

Before I touch upon the picture of the morphology of human joint fluid, I shall say a few words on the condition in animals. To judge

from the literature on the subject, the main interest so far seems to have been concentrated on the cellular components in the joint fluid of cattle, horses, and sheep. *Bauer* and his assistants showed with a supravital experiment that 90-95 % of all cells in the synovial fluid of cattle possess phagocytic potentialities. These authors

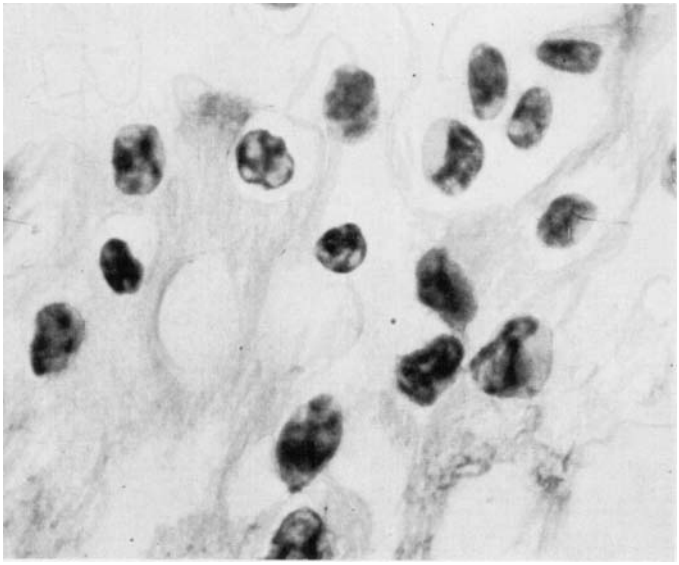

Fig. 1.
Cells in joint fluid from a cow. All cells are of a monocytic nature.

believe that such a great number of phagocytic cells argues that their *task is to remove products which may arise due to wear and tear of the joint.* They give as a mean: 91.6% phagocytes and 8.4% non-phagocytic cells. They also found red blood cells in the punctate, which, however, should be considered as an artefact. *Davies* has determined the number of cells in separate joints of different domestic animals and states that, where the cell count is large, there are many phagocytes, as long as the viscosity is high; but that with a diminishing number of cells, he found a lesser viscosity. In the latter joints too, degenerative cell types seem to appear more than in the former. It is of interest to note that in the atlanto-occipital joint he found 594 cells/mm^3 in the temporo-mandibular joint 983, but only 207 cells in the elbow joint (Table 1).

As regards cells arising from the capsule, it is stated that in synovial fluid one can normally find free synovial cells, that but a large number are found only in an inflammatory state. Synovial cells

TABLE 1

Nucleated cell content of synovial fluid in horses per cu.mm.

Joint	No. of observations	Maximum	Minimum	Average	Remarks
Atlanto-occipital	5	1162	358	594	—
Atlanto-epistrophial	10	678	346	534	—
Temporo-mandibular	14	2350	412	983*	Majority of counts were between 650 and 850
Knee	16	1638†	390	671	All specimens except three gave values between 400 and 1000
Astragalo-tibial	18	368	72	192	—
Elbow	12	336	107	207	—
Radio-carpal	17	453	50	234	—

* If three specimens of 2350, 2016 and 1588 cells per cu.mm. are excluded, the average value becomes 710.

† The opposite knee joints in one of these animals gave unusually high cell counts of 1638 and 1266 respectively.

(Davies).

which are near the joint cavity have a different appearance to other cells of the connective tissue, a fact, which caused even *Winslow* (1780) to try to place them in the epital group. The cells in question have a fine Golgi apparatus, which increases in size in a condition which is accompanied by an increased production of joint fluid (Fig. 4).

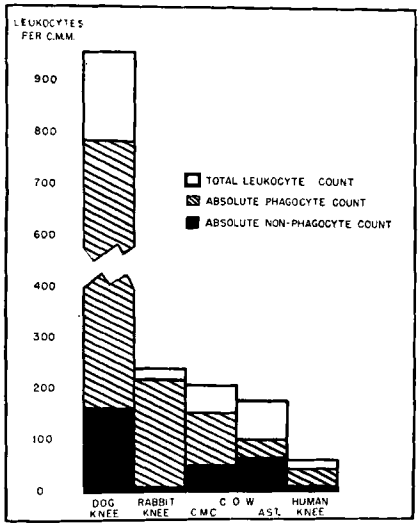

Fig. 2.

Comparison between the cell content in joint fluid from different animals.

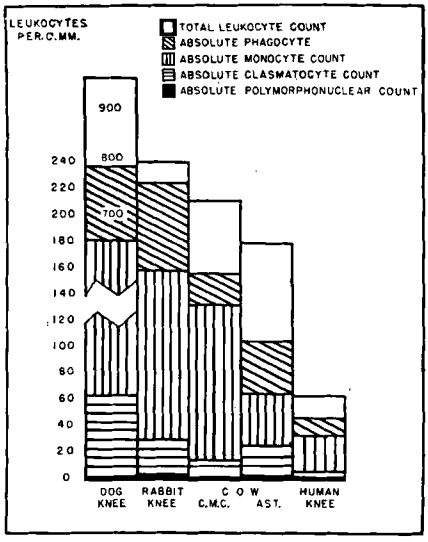

Fig. 3.

Comparison between the contents of individual cells in joint fluid from different animals.

CMC = The carpometacarpal joint. AST = The astragalotibial joint (The Talotibial joints). (Coggeshall and co-workers).

Vaubel (1938) cultivated synovial cells from rabbits, and states that they show a different development to other mesenchymal cells. They contain granules which can be coloured with neutral red and sometimes, toluidine blue, and this, it may be assumed, is the preliminary condition of the joint fluid. In cultures with growths of typical synovial cells, it should also be possible that a mucin-like substance would be produced. *Davies* (1943) in an examination of synovial cells from man and different animals argues against that theory, however. He considers that there are no secretive cells or secretive surfaces, such as *Kling*, among others, claims. Worthy of note is that, although it is true that synovial cells may be coloured with mucicarmine, this does not necessarily mean that they contain mucin. Moreover the fact that

this ability to take colour does not disappear after treatment with hyaluronidase argues directly against the theory that this substance should be mucin. The question of the importance of synovial cells in forming the joint fluid should therefore remain open.

If the information concerning the morphology of animal joint fluid

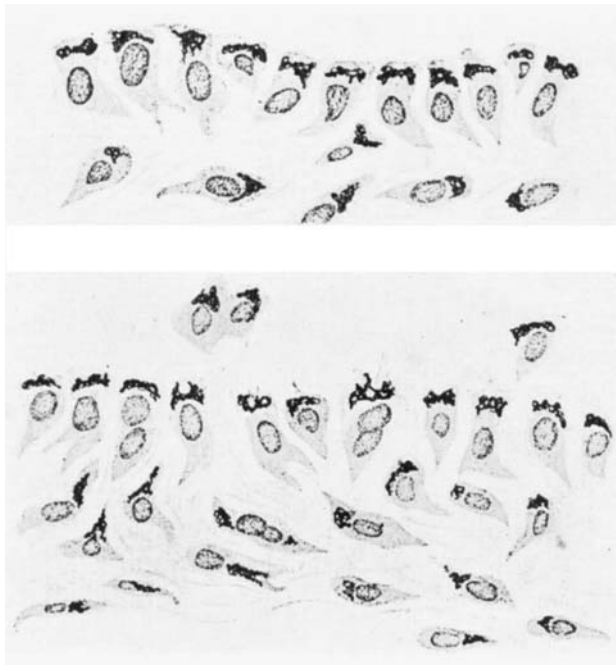

Fig. 4.
The Golgi apparatus in cells of the joint capsule.

is scanty, it is doubly so concerning human joint fluid. This is probably due, among other things, to the fact that one seldom has any entirely normal joint fluid to examine. The normal joint fluid that has been examined has come from patients with healthy joints, and has been taken after death. This means that the term "normal", must be taken with a good deal of scepticism. *Hammer* (1894) is presumably the first to have examined the joint fluid. He merely states that the cell percentage is low. *Gallon* and *von Belogh* (1919) report 16-20 cells/mm^3; *Key* (1928), 30-37.5 cells/mm^3. *Forkner* (1930) and *McEwen* (1935) give an account of the total cell content and cell types in human joint fluid. More detailed is the examination by *Coggeshall* and his assistants (1940) of joint fluid from 28 patients. The fluid was taken thirty minutes after death. They examined only the joint

TABLE 2

Phagocytic cells 69.1 %		Non-phagocytic cells 31.1 %	
Monocytes	47.9%	Lymphocytes	24.6%
Clasmatocytes	10.1%	Synovial cells	4.3%
Unclassified mononucl. cells	4.9%	Primitive cells	2.2%
Leukocytes	6.5%		

(Coggeshall et al.)

fluid from the knee. The quantity varies between 0.3-2.0 ml., values which most surely must be considered uncertain. These authors found no red blood cells; but the following cell types were found: polynuclear cells, monocytes, clasmatocytes, histiocytes, lymphocytes, and synovial cells. The number of cells varied from 13-100/mm^3.

69.1% of all the cells, were phagocytes and 31% non-phagocytes. The total number of cells was 45.4/mm^3 divided as follows: clasmatocytes, 6.7/mm^3, unclassified mononuclear phagocytes, 2.6/mm^3, polymorphonuclear leukocytes, 3.3/mm^3. The non-phagocytic cells consisted of lymphocytes, 14.7/mm^3, synovial cells, 2.5/mm^3, primitive undifferentiated cells, 0.8/mm^3. The authors state that they never saw eosinophil or basophil leukocytes in the synovial fluid. Table 2 gives the percentage division between the different cell types. In conclusion the author states that the cell content is not only an expression for, but equals, the daily wear to which the joint is subjected.

In summing up, one can say of the joint fluid morphology that the cell content is low, but that it changes from joint to joint. In animals there seems to be a certain system in this respect—namely, that the joint fluid of the limb joints is poorer in cells than that of the other larger joints. Furthermore, it would seem that the cell content and the viscosity possibly stand in a certain relation to each other. As far as different types of cell are concerned, it seems that red blood cells do not normally appear. The nuclear-carrying cells divide themselves into 2 typical groups: (1) phagocytic cells; (2) non-phagocytic cells. The former are made up of monocytes, so-called clasmatocytes and leukocytes, while the latter group consists mainly of lymphocytes and synovial cells.

SUMMARY

A survey of the literature provides but scanty details about the morphology of normal joint fluid in man. The information about the

conditions in question in animals is by contrast more rewarding. About 90-95 % of all cells in synovial fluid from cattle have phagocytic properties (91.6 % phagocytes, 8.4 % non-phagocytic cells).

Davies points out that a high cell count is accompanied by an abundance of phagocytes and high viscosity of the joint fluid. With decreasing viscosity not only is the cell count lower but degenerative cell types appear. In the joint fluid, cells of mesenchymal origin are found which secrete a mucin-like substance. In human joint fluid no one has ever discovered red blood corpuscles, but on the contrary, polynuclear cells, monocytes, clasmatocytes, histiocytes, lymphocytes and synovial cells. The number of cells is 13-100/mm^3. The cell content is low, changing from joint to joint. In animals the cell content of the smaller joints of the extremities is lower than that of the larger joints. The nuclear cells may be divided into two big groups. 1. phagocytic cells. 2. non-phagocytic cells. The first consists of monocytes, clasmatocytes and leucocytes, the latter, of lymphocytes and synovial cells.

RESUME

Un examen de la littérature donne des renseignements parcimonieux sur la morphologie du liquide séreux normal des articulations chez l'homme. Par contre, on a des données beaucoup plus complètes en ce qui concerne les animaux. 90 à 95% de toutes les cellules de la synovie des bovidés ont des propriétés phagocytaires (91,6% phagocytes, 8,4% de cellules non phagocytaires). Davies signale que lorsqu'il y a un nombre élevé de cellules on constate une abondance de phagocytes et une haute viscosité du liquide articulaire. Lorsque la viscosité diminue, non seulement le nombre des cellules tombe, mais on voit apparaître des types de cellules dégénératives. Dans le liquide de l'articulation, on trouve des cellules d'origine mésenchymale qui semblent devoir sécréter un liquide ressemblant à la mucine. Dans le liquide humain de l'articulation, on n'a jamais trouvé de globules rouges, par contre des cellules polynucléaires, des monocytes, clasmatocytes, histiocytes, lymphocytes et des cellules synoviales. Le nombre des cellules est de 13-100/mm^3. Le taux des cellules est faible, variant d'une articulation à l'autre. Chez les animaux, le taux des cellules est plus faible dans les petites articulations que dans les grandes. Les cellules nucléaires ont pu être divisées en deux groupes: 1. cellules phagocytaires et 2. cellules non phagocytaires. Le premier est constitué de monocytes, clasmatocytes et leucocytes, le dernier de lymphocytes et de cellules synoviales.

ZUSAMMENFASSUNG

Eine Durchsicht der Litteratur gibt nur sparsame Auskunft über die normale Morphologie der Gelenksflüssigkeit beim Menschen. Die Angaben über ihr Verhalten beim Tier sind hingegen ausführlicher. Ungefähr 90—95 % aller Zellen in der Synovia von Kühen haben phagozytäre Eigenschaften (91,6 % Phagozyten, 8,4 % nicht phagozytierende Zellen). Davies hebt hervor dass hohe Zellzahl eine erhöhte Menge von Phagozyten und eine hohe Viskositet der Gelenksflüssigkeit bedeutet. Bei sinkender Viskositet kommt es nie zur Verminderung der Zellanzahl ohne dass auch degenerative Zellformen auftreten. In der Gelenksflüssigkeit findet man Zellen von mesenchymalem Ursprung, die ein mucinartiges Sekret absondern sollen. In der menschlichen Gelenksflüssigkeit hat man niemals rote Blutkörperchen gefunden, hingegen fanden sich polynukleäre Zellen, Klasmatozyten, Histiozyten, Lymphozyten und Synovialzellen. Zellanzahl 13—100/mm³. Der Zellgehalt ist niedrig und wechselnd von Gelenk zu Gelenk. Bei Tieren ist der Zellgehalt der kleineren Gelenke geringer als der der grösseren Gelenke. Die kernhaltigen Zellen könnte man in zwei Gruppen einteilen. 1. Phagozytierende Zellen, 2. Nicht phagozytierende Zellen. Die ersteren bestehen aus Monozyten, Klasmatozyten und Leukozyten, die letzteren aus Lymphozyten und Synovialzellen.

REFERENCES

Bauer, W., G. A. Bennett, A. Marble and *D. Clofin:* J. Exp. Med. 52:835. 1930
Coggeshall, H. C., C. F. Warren and W. Bauer: Anat. Rec. 77:129. 1940.
Davies, D. V.: J. Anat. 78:68. 1944.
— J. Anat. 79:66. 1945.
Forkner, C. E.: J. Lab. Clin. Med. 15:1187. 1930.
Key, J. A.: J. Bone & Joint Surg. 7:666. 1926.
— Anat. Rec. 40:193. 1928.
Kling, E. S. J.: J. Path & Bact. 41:117. 1935.
Le Gros Clark, W. E.: The Tissue of the Body, Oxford 1946.