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Does joint cartilage require energy?

SIR, Geborek *et al* showed that induced increase of synovial fluid pressure decreases synovial blood flow,¹ which, as expected,² decreases synovial fluid oxygen tension.³ In five minutes synovial fluid pressure raised by flexion decreased synovial fluid oxygen tension in 3/10 cases of knee trauma; these three synovial fluids contained few red cells, potential buffers against hypoxia.⁴ Even at resting joint angles synovial fluid pressure correlated with synovial fluid hypoxia and, like synovial fluid volume, erythrocytes, and leucocytes also, with synovial fluid lactic acidosis (unpublished). Ischaemia cannot induce such changes unless oxygen and glucose are consumed.

We lack data on oxygen and glucose consumption in man, but Bywaters found that each mg of dry weight horse joint cartilage under aerobic conditions consumed 0.01 $\mu\text{l/h}$ oxygen (his Table XIII) and produced 0.171 $\mu\text{l/h}$ of lactate (Table VII), the rates in synovium being 0.8 and 1.7 $\mu\text{l/h}$ respectively.⁵ In rabbit leucocytes the rates were 4.15 (oxygen) and 22.5 $\mu\text{l/h}$ (lactate).⁶ From the surface areas in one human knee⁷ the volume of the innermost vascular synovial intima was calculated to be 0.554 cm^3 and that of cartilage 44 cm^3 .⁸ We calculated that in $\mu\text{mol/h}$ (a) this cartilage consumed 3.924 oxygen and produced 67.1 lactate (water 80%), (b) the synovial intima 5.93 oxygen and 12.6 lactate (water 70%), and (c) 10^6 leucocytes (water 75%) 0.0419 oxygen and 0.227 lactate. In each hour (d) 10^9 erythrocytes consume 0.027 μmol oxygen and produce 0.384 μmol lactate.⁹

In many cases of knee trauma (unpublished) synovial fluid leucocytes and red cells seemed to have consumed more oxygen and glucose than (required by?) the joint cartilage.

The regulation of glycolysis in cartilage differs from that in liver as entry of pyruvate into the citric acid cycle is possibly inhibited by acetyl-CoA derived from fat.¹⁰ In normal cartilage most of the energy may be produced by glycolysis, but if the oxygen consumed is used for oxidation of glucose^{10–12} (lipids?) about a quarter of the energy may depend on oxygen. In acidotic joints proper energy supply might require more oxygen as glycolysis is depressed by high lactate concentrations.

Damage by reperfusion induced oxygen radicals has been stressed³ and considered.¹ The synovial fluid oxygen tension dropped, however, at a rate (61 to 41 mmHg in two minutes)³ that might soon have resulted in anoxia and which, at synovial fluid volumes >10 ml, exceeded the calculated consumption by cartilage. We suggest that

raised synovial fluid pressure and intra-articular cells deprive cartilage of energy.^{2, 12} To avoid ischaemic metabolic joint damage one should refrain from measures that disturb circulation in capillaries of cartilage in the synovium⁸ (removed at early synovectomy) and aim instead to correct changes of physiological mechanisms that, by increasing synovial fluid volume, increase synovial fluid pressure,^{2, 14} the simplest being rinsing of joints to decrease the osmotic 'suck' of synovial fluid colloids.

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