THE EFFECT IN VITRO OF IRRIGATING SOLUTIONS ON INTACT RAT ARTICULAR CARTILAGE

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Rat patellae were preincubated with culture medium M199 for one hour and then with either fresh culture medium or Ringer’s solution, Ringer lactate, Ringer glucose, normal saline or Betadine for another hour. The rate of proteoglycan synthesis in the articular cartilage was then measured by uptake of 35SO4 for the next 16 hours.

Cartilage metabolism was inhibited by all of the solutions even after a recovery time of 16 hours. The inhibition was by 5% for Ringer’s solution, 10% for Ringer glucose (p < 0.01), 20% for saline and Ringer lactate (p < 0.001) and 55% for Betadine (p < 0.001). Ringer’s solution is therefore the best choice for joint irrigation during arthroscopy or other procedures.

A number of different solutions have been used to irrigate joints during arthroscopy and other open and closed procedures. Synovial fluid normally maintains the physiological environment within a joint and supplies nutrition to the chondrocytes (Muir 1980). During arthroscopy, it is replaced by an irrigating solution; this may impair cartilage metabolism and especially proteoglycan (PG) synthesis.

This has been investigated in different animal models, often on detached articular cartilage specimens (Reagan et al 1983; Bert et al 1990). Cartilage explants, however, show an initial period of enhanced PG synthesis in culture, with a considerable loss of PG into the culture medium (Verbruggen, Luyten and Veys 1985). Other authors (Johnson et al 1983; Arciero et al 1986; Marshall et al 1988) have also used animal models but in these experiments synovitis was found to be caused by the catheter or arthroscopic instrument (Small 1988; Kieser 1992) and this released proteolytic factors (Campbell et al 1989; Andrews and Ghosh 1990) again interfering with the results for irrigating fluids.

We therefore studied the effect of different irrigation fluids on anatomically intact cartilage, using the rat patella (De Vries et al 1986). We incubated the patellae for 16 hours to allow a relatively long recovery time after incubation with the different irrigation fluids.

MATERIALS AND METHODS

Patellae obtained from inbred, 4-week-old Lewis rats were immediately immersed in M199 culture medium (GIBCO, Paisley, UK) supplemented as shown in Table I. We tested five irrigating solutions, using supplemented M199 as a control. The solutions were sodium chloride 0.9%, Ringer’s solution, Ringer glucose 5%, Ringer lactate and Betadine (Table I). Twelve patellae were immersed in each solution and incubated for one hour, then incubated in M199 medium for one hour, and radiolabelled with 35SO4 for another 16 hours. Culture throughout was at 37°C in a humidified atmosphere of 5% CO2.

Table I. Composition of the solutions tested

<table>
<thead>
<tr>
<th>Medium M199 (Gibco, Paisley, UK) plus</th>
<th>Normal saline</th>
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<tbody>
<tr>
<td>10% fetal calf serum (Boehringer Mannheim, Germany)</td>
<td>NaCl 8.6 g</td>
</tr>
<tr>
<td>250 µg/ml L-glutamine</td>
<td>KCl 300 mg</td>
</tr>
<tr>
<td>50 µg/ml ascorbic acid</td>
<td>309 mOsm/l</td>
</tr>
<tr>
<td>500 U/ml penicillin</td>
<td>308 mOsm/l</td>
</tr>
<tr>
<td>500 µg/ml streptomycin</td>
<td>Ringer’s solution</td>
</tr>
<tr>
<td>0.125 µg/ml amphotericin B</td>
<td>NaCl 6 g</td>
</tr>
<tr>
<td>CaCl2 330 mg</td>
<td>KCl 300 mg</td>
</tr>
<tr>
<td>KCl 300 mg</td>
<td>Na lactate 3.22 g</td>
</tr>
<tr>
<td>309 mOsm/l</td>
<td>KCl 400 mg</td>
</tr>
<tr>
<td>278 mOsm/l</td>
<td>CaCl2 270 mg</td>
</tr>
</tbody>
</table>

Ringer glucose 5%

| NaCl 8.6 g | KCl 300 mg |
| CaCl2 330 mg | Glucose 500 g |
| 309 mOsm/l | Ringer lactate |
| 278 mOsm/l |

Betadine

| Povidone-iodine | Polyanvinyl pyrrolidone iodine complex |
| 100 mg/ml |

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The patellae were then washed three times in PBS and rinsed in water. Articular cartilage was removed from the subchondral bone and digested in protease K (2.5 U in 1 ml 0.05 M tris-HCl, 1 mM CaCl₂, pH 7.9). The amount of ³⁵SO₄ in the cartilage was measured by a liquid scintillation counter (Beckmann LS 3801; Beckman Instruments Inc, Anaheim, California). The results were analysed using the Mann-Whitney non-parametric test.

RESULTS

Only the patellae treated with Betadine showed macroscopic softening of the cartilage. The results for uptake of radiolabel after the use of each solution compared with that for control patellae are shown in Figure 1. The saline solution and the Ringer lactate inhibited chondrocyte metabolism by 20% (p < 0.001), Ringer's solution by 5% and Ringer glucose by 10% (both p < 0.01). Betadine showed a 55% inhibition of chondrocyte metabolism (p < 0.001) when compared with culture medium.

DISCUSSION

The ideal irrigating solution should have compatible osmotic, pH, ion and conduction properties. Water is known to have a negative effect on cartilage metabolism (Campbell 1969). The ionic concentration of normal saline resembles that of serum and other body fluids, but it is considerably more acid (pH 5.3) than most body fluids, and it also disturbs the ionic equilibrium of the cells. Our use of anatomic intact cartilage avoided leakage of proteoglycans from explants, and the rat patella has been used to study the effects of drugs on cartilage (van den Berg, Kruijssen and van de Putte 1982; De Vries 1986). It has been shown that 98% of the radiolabel is taken up by the cartilage of the patella and only 2% by bone, making it unnecessary to measure these separately.

In contrast to other reports we have clearly shown that all the irrigating solutions inhibited the metabolism of healthy cartilage. Ringer lactate has been suggested to be the more physiological irrigating fluid, but we have shown that it significantly inhibits the uptake of ³⁵SO₄ in anatomically intact patellae. Other authors do not agree (Reagan et al 1983; Arciero et al 1986) but they used cartilage slices and it is possible that such slices cultured as explants lose proteoglycans near the surface thus changing the metabolic properties of the chondrocytes.

Some authors have shown that even short-term exposure to irrigating fluids induced metabolic inhibition of chondrocytes (Johnson et al 1983; Arciero et al 1986). It has also been considered that articular chondrocytes make a quick recovery (Arciero et al 1986), but we showed definite inhibition after a recovery time of 16 hours with a prolonged exposure to the radiolabel. In vivo, recovery may well be even more inhibited by the inflammatory reaction of the synovium to the irrigating fluid and to the arthroscopic procedure (Martinez Moreno and Vaquero Martin 1986). We have shown that Ringer's solution and Ringer glucose 5% have the least inhibitory effect on cartilage metabolism. These are recommended as the most physiological irrigating solutions.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


