Bupivacaine injection of eye muscles to treat strabismus

Alan B Scott, Danielle E Alexander, Joel M Miller

Background: Bupivacaine injected into animal muscles induces a cycle of myotoxicity, degeneration, regeneration and hypertrophy of muscle fibres, without adverse effects on other tissues. This induced hypertrophy can be harnessed to treat strabismus.

Methods: Bupivacaine, 4.5 ml of a 0.75% solution, was injected into the right lateral rectus (RLR) muscle of a patient who had diplopia and who showed 14-prism-dioptres oesotropia.

Results: RLR paresis persisted for 7 days. Then, the RLR regained its abducting ability, and progressive improvement of alignment to 4-prism-dioptres oesophoria occurred over the next 33 days, with the elimination of diplopia. Alignment remained the same at 54 days after injection. Magnetic resonance imaging showed a focal increase in the size of the injected RLR of 58% in the posterior area, with reduced change in anterior portions of the RLR.

Conclusion: Injection of bupivacaine to induce hypertrophy of the injected muscle and thus alter eye alignment was effective in our patient. This approach can be a useful addition to the treatment of strabismus.

DISCUSSION

Bupivacaine injection of muscle in laboratory animals results in immediate and massive degeneration of muscle fibres, with dissolution of myofibrils at the Z-band. Other structures are substantially unchanged, including the basal lamina, the satellite cells of which form the muscle fibres, and nearby nerves and vasculature. Inflammatory cells and macrophages remove the degenerated muscle fibres over 2–10 days time. Beginning at about day 2, satellite cells are activated and regeneration begins with the muscle reaching pre-injection size and strength around day 21. The satellite cells continue to elaborate new fibres, with the resulting hypertrophy continuing for many days, and with the muscle remaining enlarged for at least 180 days. The participation of satellite cells in eye muscle function and the signals that control their activation are related fields of great interest. We suppose that the strabismus after cataract surgery also results from muscle hypertrophy induced by bupivacaine. Fibrosis and...
scarring, the current putative causes for such strabismus, have not been documented by biopsy, nor found in animal injection studies. Furthermore, the modelling program-Orbit 1.8™ (Eidactics, San Francisco) indicates that muscle hypertrophy, not shortening or stiffening from scarring, can explain the overaction pattern characteristic of these cases. Hypertrophy also occurs after injection of denervated muscle in animals, auguring well for therapeutic trials in paretic strabismus. Accurate measurement of eye muscle sizes, forces and changes in alignment are under way in animals and humans in order to define the optimum volume of injection, drug dosage and location in the muscle for injection. It has not escaped our notice that extension of this approach to other muscles holds much promise.

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