Rotator Cuff Healing Following Continuous Subacromial Bupivacaine Infusion

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INTRODUCTION
As arthroscopic shoulder procedures are increasingly performed on an outpatient basis, there is a need for localized post-operative pain management. Continuous infusion of bupivacaine into the joint has offered effective pain management, but has also shown chondrotoxicity in vitro, in animal models, and in the clinical setting. These findings have led to the abandonment of intra-articular placement and the advent of subacromial placement. Subacromial placement of bupivacaine may avoid direct exposure of the drug to the articular cartilage. However, bupivacaine has also been shown to be toxic to both skeletal muscle and tendon fibroblasts, thus raising concern regarding whether this toxicity compromises rotator cuff tendon healing.

The objective of this study was to elucidate the effects of continuous subacromial bupivacaine infusion on supraspinatus muscle and rotator cuff tendon healing via gross, histologic, and biomechanical analyses.

METHODS
Thirty-three male New Zealand White rabbits underwent unilateral supraspinatus transection and rotator cuff repair (RCR). Rabbits were randomized to one of three treatment groups (n=11 animals per group) consisting of unilateral rotator cuff repair with (A) no drug treatment (RCR Only), (B) continuous saline infusion into the subacromial space for 48 hours, or (C) continuous 0.25% bupivacaine with epinephrine (1:200,000) infusion into the subacromial space for 48 hours. Intact contralateral shoulders served as controls.

Rabbits were further randomized to either a 2 week (n=2 per group) or 8 week (n=9 per group) post-operative endpoint. At the 2 week endpoint, the supraspinatus enthesis and muscle were histologically evaluated. At the 8 week evaluation, supraspinatus enthesis and muscle histology (n=2 per group) as well as supraspinatus tendon biomechanical properties (n=7 per group) were assessed.

Specimens assigned to muscle histology were harvested proximal to the myotendinous junction, paraffin embedded, sectioned transversely, and stained with hematoxylin and eosin. For biomechanical testing, the proximal humerus was potted in dental cement and a cryogenic clamp secured the supraspinatus muscle during tensile loading. Tendons were preloaded and elongated to failure at 0.1 mm/sec until failure. Surface strains for each tendon were quantified optically using a 1 megapixel digital video camera and Digital Motion Analysis System software. Surface strains were additionally computed for the regions depicted in Figure 1.

RESULTS
Macroscopic Analysis
Macroscopically, in all tendons receiving RCR, scar tissue was localized to the injury site. No necrosis was noted in muscle or tendon.

Muscle Histology
Muscle histology demonstrated edema and void spaces in both the RCR Saline and RCR Bupivacaine groups at 2 weeks, but no edema in either at 8 weeks. Scattered degenerative muscle fibers were noted at 2 weeks in both RCR Saline and RCR Bupivacaine (Figure 2), but no degeneration was noted at 8 weeks, suggesting a recovery period to any acute damage. No differences in muscle histologic features between groups were noted at 8 weeks.

Figure 2: Degenerated muscle fiber at 2 weeks post-op (RCR Bupivacaine)

Enthesis Histology
At two weeks post-op, all specimens that underwent RCR, regardless of infusion status, demonstrated increased cellularity, disruption of normal fiber orientation, and disruption of the original four zone insertion. At eight weeks post-op, inflammatory cells were absent and collagen fibers exhibited improved alignment. No differences were seen among the three treatment groups.

Rotator Cuff Tendon Biomechanics
Tensile testing showed significantly higher load to failure in intact tendons (375 ± 45N) compared to repaired tendons (p<0.01); however, no statistical differences were detected among RCR only (222 ± 58N), RCR Saline (245 ± 64N), and RCR Bupivacaine (229 ± 52N) groups.

Similar statistical trends were noted for linear stiffness (p<0.01), work to peak load (p<0.01), and maximum stress (p<0.01), where intact tendons exhibited superior properties in comparison to the repaired tendons. (Figure 3)

Figure 3: Maximum load to failure

DISCUSSION
Subacromial bupivacaine infusion may avoid chondrotoxicity, but concern exists regarding bupivacaine’s effects on muscle tissue and tendon healing. Previous in vitro studies have demonstrated myotoxicity following administration of local anesthetic as well as bupivacaine’s in vitro toxicity to fibroblasts. Fibroblasts are essential in the healing response following RCR, and thus bupivacaine’s use brings considerable concern regarding its effects on muscle tissue and tendon healing.

In the present study of a rabbit model of RCR at 2 and 8 weeks post-operatively, muscle histology shows fiber damage at 2 weeks for both the saline and bupivacaine treated groups, with no apparent disruption at 8 weeks, suggesting a recovery process. The healing supraspinatus tendons exposed to 48 hours of continuous bupivacaine infusion showed similar histologic and biomechanical characteristics compared to untreated and saline infused RCR groups. Therefore, bupivacaine infusion in this rabbit rotator cuff model likely does not have impair tendon healing following acute injury and repair.

We conclude that definitive contraindications to subacromial bupivacaine infusion for pain management following RCR are not supported by the results of this study. Further investigation may be necessary to determine the effects of bupivacaine in a chronic injury model.

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REFERENCES