

Myofibroblasts Alter Tension and Strain of Cardiac Fiber: A Computational Study

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Aims: In heart pathological conditions, fibroblasts proliferate and differentiate into myofibroblasts. In previous study, we have found that the $\text{Na}_v 1.5 \alpha$ subunit, which generates a persistent Na^+ current in myofibroblasts ($I_{\text{Na_myofb}}$), regenerated action potentials (APs) in myocytes and myofibroblasts. In this study, we added $I_{\text{Na_myofb}}$ to the myofibroblast model, and aimed to investigate the role of myofibroblasts on the mechanical contraction of cardiac fiber.

Methods: Mathematical modeling was done using a combination of (1) the Maleckar et al. model of the human atrial myocyte, (2) the MacCannell et al. “active” model of the human cardiac myofibroblast, (3) our formulation of $I_{\text{Na_myofb}}$ based upon experimental findings from Chatelier et al., and (4) the Hill three-element rheological scheme of a single segment of cardiac fiber. For myofibroblast-myocyte coupling, different ratios of myocytes to myofibroblasts were set based on available physiological data. Both isometric contraction and isotonic contraction were considered to illustrate the effect of myofibroblasts on cardiac fiber’s tension and strain.

Results: The simulation results showed that (1) myofibroblasts reduced the fiber peak force in isometric contraction and the fiber peak strain in isotonic contraction, and (2) increased the time to peak strain and the relaxation time in both contractions.

Conclusion: The identified effects demonstrated that myofibroblasts play an important role of modulating cardiac mechanical behavior. It should be considered in future pathological cardiac mathematical modeling, such as atrial fibrillation and cardiac fibrosis.