Mechanism of heart regeneration by cardiosphere-derived cells

Reporting Period: Year 1

Key abbreviations: CDCs: cardiosphere-derived cells MI: myocardial infarction The present award tests the hypothesis that CDCs promote regrowth of normal mammalian heart tissue through induction of adult cardiomyocyte cell cycle re-entry and proliferation (as occurs naturally in zebrafish and neonatal mice). Such a mechanism, if established, would challenge the dogma that terminally-differentiated adult cardiomyocytes cannot re-enter the cell cycle. We have employed an inducible cardiomyocyte-specific fate-mapping approach (to specifically mark resident myocytes and their progeny), coupled with novel methods of myocyte purification and rigorous quantification. We have also developed assays that enable us to exclude potential technical confounding factors. The use of bitransgenic mice is essential for our experimental design (as it enables fate mapping of resident myocytes in a mammalian model), while the use of mouse CDCs in our in vivo experiments (as opposed to human CDCs) enables us to avoid immunosuppression and its complications. To date, mouse, rat and pig models have proven to be reliable in predicting clinical effects of CDC therapy in humans, and results with human and mouse CDCs in comparable models (e.g., SCID mice for human CDCs versus wild-type mice for mouse CDCs) have not revealed any major mechanistic divergence. Our results demonstrate that induction of cardiomyocyte proliferation represents a major, previously-unrecognized mechanism of cardiac regeneration in response to cell therapy. One full-length publication describing these findings has appeared (K. Malliaras et al., EMBO Mol Med, 2013, 5:191-209), and another paper has been submitted. The work has already begun to open up novel mechanistic insights which will enable us to improve the efficacy of stem cell-based treatments and bolster cardiomyocyte repopulation of infarcted myocardium.

Reporting Period: Year 2

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Reporting Period: Year 3

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Mechanism of heart regeneration by cardiosphere-derived cells

Grant Type: Basic Biology IV
Grant Number: RB4-06215
Project Objective: To investigate the mechanism of heart regeneration by cardiosphere-derived cells (CDCs) and test the hypothesis that CDCs promote regrowth of normal mammalian heart tissue through induction of adult cardiomyocyte cell cycle re-entry and proliferation.

Investigator:
Name: Eduardo Marbán
Institution: Cedars-Sinai Medical Center
Type: PI

Disease Focus: Heart Disease
Human Stem Cell Use: Adult Stem Cell
Award Value: $1,367,604
Status: Closed
Application Title: Mechanism of heart regeneration by cardiosphere-derived cells
**Public Abstract:**
In the process of a heart attack, clots form suddenly on top of cholesterol-laden plaques, blocking blood flow to heart muscle. As a result, living heart tissue dies and is replaced by scar. The larger the scar, the higher the chance of premature death and disability following the heart attack. While conventional treatments aim to limit the initial injury (by promptly opening the clogged artery) and to prevent further damage (using various drugs), regenerative therapy for heart attacks seeks to regrow healthy heart muscle and to dissolve scar. To date, cell therapy with CDCs is the only intervention which has been shown to be clinically effective in regenerating the injured human heart. However, the cellular origin of the newly-formed heart muscle and the mechanisms underlying its generation remain unknown. The present grant seeks to understand those basic mechanisms in detail, relying upon state-of-the-art scientific methods and preclinical disease models. Our work to date suggests that much of the benefit is due to an indirect effect of transplanted CDCs to stimulate the proliferation of surrounding host heart cells. This represents a major, previously-unrecognized mechanism of cardiac regeneration in response to cell therapy. The proposed project will open up novel mechanistic insights which will hopefully enable us to boost the efficacy of stem cell-based treatments by bolstering the regeneration of injured heart muscle.

**Statement of Benefit to California:**
Coronary artery disease is the predominant cause of premature death and disability in California. Clots form suddenly on top of cholesterol-laden plaques in the wall of a coronary artery, blocking blood flow to the heart muscle. This leads to a “heart attack”, in which living heart muscle dies and is replaced by scar. The larger the scar, the greater the chance of death and disability following the heart attack. While conventional treatments aim to limit the initial injury (by promptly opening the clogged artery) and to prevent further injury (using various drugs), regenerative therapy for heart attacks seeks to regrow healthy heart muscle and to dissolve scar. To date, cell therapy with CDCs is the only intervention that has been shown to be clinically effective in regenerating the injured human heart. However, the cellular origin of the newly-formed heart muscle and the mechanisms underlying its generation remain unknown. The present grant seeks to understand those basic mechanisms in detail, relying upon state-of-the-art scientific methods and preclinical disease models. The resulting insights will enable more rational development of novel therapeutic approaches, to the benefit of the public health of the citizens of California. Economic benefits may also accrue from licensing of new technology.

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