The Role of Adult Bone Marrow Stem Cells in the Heart Muscle Tissue Repair

How does the use of bone marrow stem cell therapy affect cardiac function and regeneration of cardiac tissue following a myocardial infarction?

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Abstract

Heart attacks are a significant issue for the elderly. Current methods for treating heart attacks do not account for the weakening of the heart muscle tissue following a heart attack. Studies have looked into the potential usage of bone marrow stem cells to regenerate heart tissue after heart attacks.

Introduction

Heart attacks, or myocardial infarctions, affect over seven million people in the US per year (Mozaffarian et al 2015). These are caused by blood clots restricting blood flow to the heart, cutting off oxygen supply to the heart. As a result of deoxygenation, some heart tissues that were receiving oxygen from the now clotted artery die. These heart attacks cause long term damage to the muscle tissue in the heart and further increase heart risk.

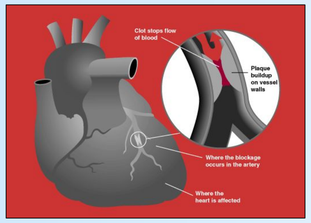


Figure 1: Displays the heart and a restricted artery affecting cardiac tissue

Stem cells are cells which are capable of differentiating, cloning, or self replicating into other cells. Stem cells aim to replace dead or damaged normal cells to keep the organ or tissue healthy and functional. The stem cells themselves are unspecialized, but instead give rise to specialized cells. TThose adult stem cells can be injected into the infarcted area in the heart to restore the damaged tissue and improve cardiac function.

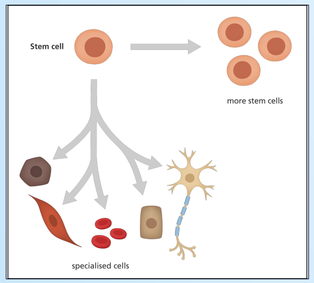


Figure 2: Stem cell function to self-replicate or differentiate into specialized cells.

Purpose

The purpose of this study is to analyze the feasibility of using bone marrow stem cells to treat patients who have suffered heart attacks. The goal is to regenerate or reform infarcted tissue areas of the heart to restore it to its maximum function.

Hypothesis

Stem cells from bone marrow can successfully be used in humans to repair infarcted heart tissue and improve cardiac function damaged by myocardial infarction.

Timeline

Step 1 → **Step 2** → **Step 3** → **Step 4** → **Step 5**

Step 1	Step 2	Step 3	Step 4	Step 5
Current literature review	Accumulated data on clinical trials	Analyzed data using statistical analysis	Conclusions Discussion Implications	Communicate findings

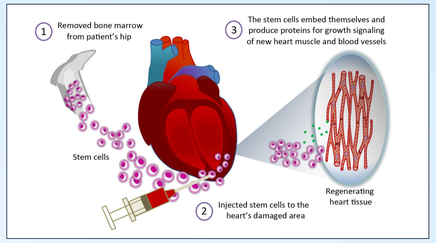
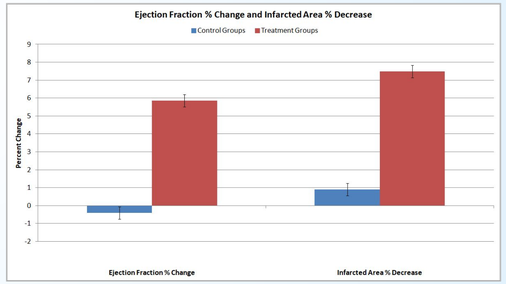


Figure 3: Successful stem cell integration into cardiac tissue

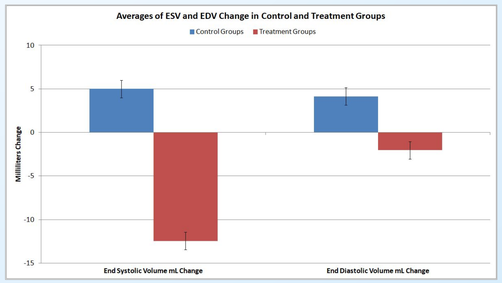
Results

Study Analyzed	Number of patients in study (control, treatment)	Time elapsed to follow up examination	Number of Adverse Events in Control Group	Number of Adverse Events in Treatment Group
Heldman et al (2014) (MSC)	11,19	12 months	4	8
Heldman et al (2014) (BMC)	10,19	12 months	4	10
Perin et al (2012)	27,52	6 months	0	0
Grajek et al (2009)	12,27	12 months	8	9
Piepoli et al (2010)	19,19	12 months	9	7
Quyyumi et al (2011)	15,16	6 months	4	7
Bartunek et al (2013)	15,21	6 months	2	1
Turan et al (2012)	20,42	12 months	0	0
Srimahachota et al (2011)	12,11	6 months	0	0
Pokushalov et al (2010)	33,49	12 months	21	6
Traverse et al (2010)	10,30	6 months	0	1
Yerebakan et al (2011)	14,26	32-99 months	2	2
Strauer et al (2010)	168,184	60 months	32	7
Perin et al (2011)	10,20	6 months	0	0
Rodrigo et al (2013)	38,8	12 months	4	1
Total	412,543	-	90	51

Table 1. The chart displays all studies included in the data analysis, their number of patients in control groups and treatment groups, time from treatment to follow up exam, and adverse events in each group. Abbreviations: MSC: Mesenchymal stem cells, BMC: Bone marrow stem cells.



Graph 1: Comparison of averages of ejection fraction and infarcted area change in control and treatment groups. Error bars represent 95% confidence intervals.



Graph 2: Comparison of averages of end systolic and end diastolic volume change in control and treatment groups. Error bars represent 95% confidence intervals.

Discussion

The use of autologous bone marrow stem cells is feasible in all of the studies. They are a desirable source for cardiac repair due to their accessibility for harvest, attribute for self-replication, and extensive previous clinical experience (Hare et al 2009).

The decreased amount of adverse events experienced by the treatment groups compared to the control groups may be due to decreased numbers of cardiac arrhythmias, an irregular beating of the heart (Strauer et al 2010). A weaker left ventricular function increases the likelihood of lethal cardiac arrhythmias which leads to sudden cardiac death. It is possible that the implementation of bone marrow stem cells improved left ventricular function and reduced chances of cardiac death.

An improvement of ejection fraction allowed the heart to more efficiently move blood throughout the body with fewer heartbeats, leading to longer heart longevity and health because the heart does not have to strain itself to provide oxygen to vital tissues.

Conclusion

Compiling these clinical trials showed that bone marrow stem cell usage has promise in increasing ejection fraction while decreasing end systolic volume. Therefore, applications of bone marrow stem cell therapy will prevent further damage to the patient by regenerating necrotic myocardial tissue.

Further Work

Because there have been few experiments conducted over a extended time period with a large number of patients, future studies in this subject should focus on a much larger sample size over a time period of multiple years. Although important factors to control for include patient characteristics, it is nearly impossible to have uniform patient populations in individual studies. Therefore, randomization and controlled trials are necessary to minimize possible errors. Further clinical trials should look into standardizing measurement methods and injection methods to determine proper efficacy of stem cell treatment. With such high variance in methods, patient population, and measurements, it is necessary to determine one way to decide the efficacy of stem cell treatment.

References

1. Heldman, A. W., DiFede, D. L., Fishman, J. E., Zambrano, J. P., Trachtenberg, B. H., Karantalis, V., ... & Ghersin, E. (2014). Transendocardial mesenchymal stem cells and mononuclear bone marrow cells for ischemic cardiomyopathy: the TAC-HFT randomized trial. *Jama*, *311*(1), 62-73.
2. Perin, E. C., Willerson, J. T., Pepine, C. J., Henry, T. D., Ellis, S. G., Zhao, D. X., ... & Martin, A. D. (2012). Effect of transendocardial delivery of autologous bone marrow mononuclear cells on functional capacity, left ventricular function, and perfusion in chronic heart failure: the FOCUS-CCTRN trial. *Jama*, *307*(16), 1717-1726.

For further references, see academic paper