Intraperitoneal Injection of Oxygenated Perfluorochemical Improves the Outcome of Intraportal Islet Transplantation in a Rat Model

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Transplantation Proceedings, 38(10):3289-3292

2006-12

Journal Article / 学術雑誌論文

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10.1016/j.transproceed.2006.10.183

http://www.lib.kobe-u.ac.jp/handle_kernel/90000831

PDF issue: 2019-01-10
INTRAPERITONEAL INJECTION OF OXYGENATED PERFLUOROCHEMICAL IMPROVES
THE OUTCOME OF INTRAPORTAL ISLET TRANSPLANTATION IN A RAT MODEL

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Grant support
This work was supported in part by a grant for 21st Century COE Program,
"Center of Excellence for Signal Transduction Disease: Diabetes
Mellitus as Model" from Ministry of Education, Culture, Sports,
Science and Technology of Japan.
INTRODUCTION

Islet transplantation has become a clinical option to restore insulin independence to patients with unstable type 1 diabetes mellitus. But one of major obstacles for successful islet transplantation from one donor is early graft loss on islet engraftment. There is a suggestion that as many as 50-75 % of islets fail to engraft following intraportal islet transplantation (IPIT)\(^1\). Since reconstruction of blood supply with vessel anastomosis cannot be performed in islet transplantation in contrast to pancreas transplantation, hypoxia should contribute to islet graft loss in the immediate post-transplantation. Perfluorochemical (PFC) has ability as a high oxygen carrier and we published its efficacy to oxygenate the pancreas during the preservation by the two-layer method\(^2-4\). Here we examined the effect of intraperitoneal oxygenated PFC on the outcome of IPIT.

MATERIALS AND METHODS

Animals

Male Lewis rats weighing 250-300 g were used in this study. Diabetes was induced in recipient rats by intraperitoneal injection of 65mg/kg body weight streptozotocin. Recipients were considered diabetic if their non-fasting blood glucose levels exceeded 350 mg/dl for 3 consecutive days. All animals were maintained in animal care facilities in accordance with the “Guidelines for Animal Experimentation at Kobe University Graduate School of Medicine”.
**Islet Isolation and Transplantation**

The pancreas was removed under anesthesia with diethyl ether and distended by intraductal injection of 6cc collagenase solution (1mg/cc of Collagenase P (Roche, Indianapolis, IN) in Hanks’ balanced salt solution (HBSS; Sigma, St. Louis, MO)), maintaining the injection pressure at 80 mmHg. After digestion, islets were purified with a discontinuous density gradient by using Histopaque 1077 (Sigma, St. Louis, Mo) and HBSS. The crude number of islets in each diameter class was determined by counting after diphenylthioncarbazone staining using an optical graticule. This number was then converted to the standard number of islets equivalents (IEQ; diameter standardizing to 150 µm).

Islets in 0.6cc HBSS were transplanted into the portal vein of a diabetic syngeneic rat anesthetized by pentobarbitalsodium. Before closure of the abdomen, a 5Fr intravenous catheter for cut-down (Atom Medical Company, Tokyo, Japan) was inserted into the abdominal cavity through the subcutaneous tunnel in order to inject the PFC intraperitoneally and remove it if necessary.

**Experimental design**

First, syngeneic IPIT of 1000, 1500, and 2200 IEQ were performed in order to determine the marginal dose in this study. Daily blood glucose levels for 4 weeks after IPIT were measured. Success of transplantation was defined as maintenance of normoglycemia (<200 mg/dl) for at least 3 consecutive days.

Second, in group 1, oxygenated PFC was intraperitoneally injected on the transplant day and replaced every 6 hours for 2 days following
IPIT. On the other hand, in group 2, PFC with no oxygen, which was saturated by 100% nitrogen, was administered in the same manner. Daily blood glucose levels for 4 weeks after IPIT were measured and intraperitoneal glucose tolerance tests (IPGTT) were examined on the 28th post-transplant day.

**Statistical analysis**

Results were expressed as mean ± standard deviation and the statistical differences between 2 groups were determined using Fisher’s exact test and the Mann-Whitney U test, where appropriate.

**RESULTS**

Islet yield from one donor rat was $2350 ± 200$ IEQ ($1070 ± 90$ islets) with >90% purity in this study. The success rates of IPIT of 1000, 1500, 2200 IEQ without PFC were 0/6, 1/6, and 6/6, respectively. We used islets of 1500 IEQ for the following transplant experiment.

The success rate of 1500IEQ IPIT was 5/6 in group 1 in contrast with 1/6 in group 2 (p<0.05) (Fig 1). The calculated area under the curve of the glucose profile on IPGTT in group 1 was $30500 ± 5500$ mg/dl/120 min, which was significantly smaller than that in group 2 ($47500 ± 6800$ mg/dl/120 min; p<0.01) (Fig 2).

**DISCUSSION**

We show that intraperitoneal oxygenated PFC improves the outcome of IPIT. Hypoxia is thought to be an important factor influenced on the survival of intraportal islets in the immediate post-transplant period. From the same viewpoint, Hughes et al. previously reported
that inspiration of hyperoxia could improve the islet engraftment.

However, hyperoxia clearly contributes to lung toxicity and recipient’s restraint under intubation if the FiO2 is maintained more than 0.5, which are thought to be less clinical relevant. On the other hand, we found in the preliminary data that intraperitoneal PFC could oxygenate the portal vein without adverse events such as ileus and organ dysfunction on blood data. On these points, intraperitoneal injection of oxygenated PFC is thought to be a safer and more feasible method to improve islet engraftment, resulting in successful IPIT with less than marginal dose.
References


**Figure Legends**

Fig 1. The daily blood glucose levels after 1500IEQ IPIT. The success rates were 5/6 in group 1 (A) and 1/6 in group 2 (B) (p<0.05 vs group 1).

Fig 2. Intraperitoneal oxygenated PFC improved the glucose profile on IPGTTs on the 28\textsuperscript{th} post-transplant day. (A) IPGTTs in group 1. (B) IPGTTs in group 2.
Fig 1.

(A) Blood sugar level (mg/dl)

(B) Blood sugar level (mg/dl)
Fig 2.

(A) Blood sugar level (mg/dl)

(B) Blood sugar level (mg/dl)