

# Increased frequency of myeloid-derived suppressor cells facilitating skin allograft survival in aged mice

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## Research

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# Abstract

**Background** More and more aged people have organ transplantation recently. Aging process may have an influence on immunity, which conducts an adjustment of immunosuppressive agents to prevent adverse effects. Understanding of aging effects on immunity will be helpful for post-transplant care of aged recipients.

**Results** A mouse model using C3H mice as donors and aged/young C57BL/10J mice as recipients was employed to study the aging effects on immunity. The frequency of CD4 + , CD8 + and native CD4 + foxp3 + regulatory T-cells in the spleen were not different between aged and young mice. However, the frequency of CD11b + Gr-1 + myeloid-derived suppressor cells (MDSC) was higher in aged mice ( $4.4 \pm 1.4\%$  versus  $1.6 \pm 1.1\%$ ,  $p=0.026$ ). To measure cytokines in the serum, the level of TGF- $\beta$  was higher in aged mice than in young mice ( $21.04 \pm 3.91\text{ng/ml}$  versus  $15.26 \pm 5.01\text{ng/ml}$ ,  $p = 0.026$ ). In vitro, enriched T-cells from aged mice had lower proliferation capacity ( $0.350 \pm 0.003$  O.D. versus  $0.430 \pm 0.017$  O.D. at responders/stimulatory cells = 100/1) and lower Ag-specific cytotoxic ability ( $21.2 \pm 3.0\%$  versus  $39.3 \pm 4.8\%$  at target cell/effector cells = 1/100,  $p=0.003$ ) than T-cells from young mice. In vivo, the skin allografts survived on aged recipients was  $19.7 \pm 5.2$  days, compared  $11.9 \pm 4.1$  days on young mice ( $p = 0.005$ ). When entinostat was applied to aged mice to block MDSC, the survival of skin allografts was shorten to  $13.5 \pm 4.7$  days which was not different from the survival on young mice ( $p = 0.359$ ).

**Conclusion** The allogeneic immunity was lower in aged than in young mice evidenced by a higher frequency of MDSC, higher serum level of TGF- $\beta$ , decreased function of T-cells, and easy-to-induced regulatory T-cells in aged mice. Blocking the function of MDSC reversed the low immunity in aged mice and cause skin allograft rejection similar to young recipients.

## Background

Organ transplantation is widely accepted as the final treatment for the patients with a specific organ failure or even multi-organ failure. In solid organ transplantation, graft/patient survival is much improved recently because of the advances in immunosuppressive management, surgical techniques and peri-operative care. Among these advances, immunosuppressive management is most important because it is not only employed to prevent acute rejection in the short-term but also contribute to long-term graft/patient survival. However, heavy loading of immunosuppressants may be complicated with the adverse effects including neurotoxicity, nephrotoxicity, hypertension, hyperglycemia, bone marrow suppression, gastrointestinal disturbance, and so on.(1–3) Heavy immunosuppressants may also inhibit hosts' defensive immunity, increase the risk of opportunistic infection and induce the development of neoplasms.(4–6) Therefore, suitable levels of immunosuppressive agents are essential to keep allografts with good function and prevent the adverse effects of organ transplantation.(7)

Currently, aging people is increasing. Many and many aged people may have organ transplantation. In OPTN/SRTR report in 2015, liver transplant recipients above aged 65 years were increased from 9.2% in

2003 to 16.3% in 2013.(8) The immunity in aged people is weaker than that in young people.(9) In the literature, a narrower repertoire of T-cells and senescent T-cells to decrease the defending abilities to viral infection were reported.(10, 11) Therefore, the dosage of immunosuppressive agents should be minimized in aged people to avoid over-immunosuppression-related morbidities(12). However, what are the basic reasons beyond T-cells that immunosuppressive agents can be minimized for aged people is not clearly defined.

In this study, we designed a mouse model using aged and young C57BL/10J (B10) mice as recipients to define the aging effects on immunity. The understanding of aging effects on immunity is helpful for post-transplant care of aged recipients in the future.

## Results

**Immune cell population in aged mice.** To determine the alteration of immune cell population in aged mice, the spleens were obtained from aged and young mice to yield spleen cells. The spleen cells were stained by a panel of monoclonal antibodies and analyzed by flow cytometry. The results showed that the frequency of CD4<sup>+</sup> T-cells in aged mice (n = 7) was  $14.6 \pm 2.9\%$  compared to  $16.5 \pm 1.2\%$  in young mice (p = 0.185) and CD8<sup>+</sup> T-cells in aged mice was  $8.4 \pm 1.6\%$  compared to  $8.9 \pm 0.7\%$  in young mice (p = 0.324). The frequency of T-cells was not different between aged and young mice. The frequency of native regulatory T-cells (CD4<sup>+</sup>foxp3<sup>+</sup>) in aged and young mice was not different, either ( $0.4 \pm 0.6\%$  versus  $1.0 \pm 0.8\%$ , p = 0.160). However, the frequency of myeloid-derived suppressor cells (MDSC; CD11b<sup>+</sup>Gr-1<sup>+</sup>) in aged mice was  $4.4 \pm 1.4\%$  which was higher than  $1.6 \pm 1.1\%$  in young mice (p = 0.026, Fig. 1).

**Cytokine measurements in serum.** To determine whether the common cytokines in serum were different in aged and young mice, IL-12, IL-10, IFN- $\gamma$  and TGF- $\beta$  were measured. The result showed that the level of TGF- $\beta$  was higher in aged mice than young mice ( $21.04 \pm 3.91$  ng/ml versus  $15.26 \pm 5.01$  ng/ml, p = 0.026). The levels of IL-12, IL-10 and IFN- $\gamma$  were not different between aged and young mice.

**Immunological reactions of direct antigen presentation in aged recipients.** Bone marrow-derived C3H dendritic cells (DC) was employed as donor antigen-presenting cells and enriched T-cells from aged and young B10 mice were employed as recipients' cells to perform mixed lymphocyte reaction (MLR). The C3H DC cultured in GM-CSF and IL-4 expressed mature phenotype with high levels of CD40, CD80, CD86 and I-A<sup>k</sup> (Fig. 2a). When this mature C3H DC was applied to activate enriched T-cells derived from aged or young B10 mice, MLR showed that proliferation capacity of T-cells from aged mice was lower than those from young mice ( $0.350 \pm 0.003$  optic density (O.D.) versus  $0.430 \pm 0.017$  O.D. at responders/stimulatory cells = 100/1, p = 0.001) (Fig. 2b).

**Cytotoxic abilities of T-cells derived from aged mice.** T-cells derived from aged and young B10 mice were activated by C3H DC for 3 days and employed as effector cells to perform antigen (Ag)-specific and non-specific cytotoxic abilities. R1.1 cells (H-2<sup>k</sup>, allogeneic), p815 cells (H-2<sup>d</sup>, third party) and Yac-1 cells (non-Ag-specific, nature killer-sensitive) were used as target cells. The results showed that T-cells derived from

aged mice had a lower Ag-specific cytotoxic ability than T-cells derived from young mice ( $21.2 \pm 3.0\%$  versus  $39.3 \pm 4.8\%$  at target cell/effector cells = 1/100,  $p = 0.003$ ) (Fig. 3a). Even for the third party targets, T-cells derived from aged mice also had a lower cytotoxic ability than T-cells derived from young mice ( $6.0 \pm 0.6\%$  versus  $11.0 \pm 2.7\%$  at target cell/effector cells = 1/100,  $p = 0.017$ , Fig. 3b). For non-specific targets, the cytotoxic ability of T-cells derived from aged or young mice were not different. ( $28.6 \pm 0.6\%$  versus  $32.8 \pm 3.5\%$  at target cell/effector cells = 1/100,  $p = 0.100$ , Fig. 3c),

Inducible regulatory T-cells in aged mice. To determine whether regulatory T-cells could be induced in vitro, enriched T-cells derived from aged and young B10 mice were activated by C3H DC for 3 days and  $CD4^+foxp3^+$  cells were examined. The results showed that a higher frequency of  $CD4^+foxp3^+$  regulatory cells was induced in T-cells derived from aged mice than young mice ( $7.87 \pm 3.42\%$  versus  $5.04 \pm 2.71\%$ ,  $p = 0.023$ ) (Fig. 4).

Immunological reactions of indirect antigen presentation in aged recipients. To determine whether immune reactions with indirect antigen presentation was altered in aged mice, C3H DC and B10 aged/young enriched T-cells were put in a transwell of B10 DC cultural system. B10 DC was pulsed with C3H splenocyte lysate overnight and used as stimulators to activate B10 enriched T-cells. The result showed that the proliferating capacities of T-cells activated by B10 DC with C3H DC and aged B10 T-cells in transwell were lower than B10 DC with C3H DC and young B10 T-cells in transwell ( $0.328 \pm 0.004$  O.D. versus  $0.491 \pm 0.008$  O.D. at responders/stimulatory cells = 100/1,  $p = 0.001$ ) (Fig. 5)

Survival of skin allograft survival. To determine whether allograft survival was different in aged and young recipients, skin grafts from C3H mice were transplanted to aged ( $n = 20$ ) and young ( $n = 11$ ) B10 mice and survival time was recorded. To determine whether MDSC played an important role of immunosuppression in aged mice, a half of aged mice was fed with entinostat (50 mg/kg/week, Selleck Chemicals, Houston, Tx) after skin transplantation. The results showed that the skin allograft survival on young B10 mice was  $11.9 \pm 5.2$  days and was prolonged to  $19.7 \pm 5.2$  days on aged mice ( $p = 0.005$ ). When the aged mice was fed with entinostat to inhibit MDSC, the survival of skin grafts was shorten to  $13.5 \pm 4.7$  days, which was significantly shorter than the survival on aged mice without entinostat feeding ( $p = 0.042$ ) and not different from the survival on young mice ( $p = 0.359$ , Fig. 6).

## Discussion

The different frequency of immune cells in aged and young mice was mainly in MDSC. By analyzing the immune cells in the spleen, the frequency of  $CD4^+$  T-cell,  $CD8^+$  T-cells and regulatory T-cells were not different between aged and young mice. However, the frequency of MDSC in aged mice was higher than in young mice. MDSC is a well-known immune-suppressor cell which is associated with cancer, sepsis, chronic inflammation, trauma, etc.(13, 14) While the frequency of MDSC increases, the immunity of the hosts is suppressed. Hurez et al in their study described that MDSC was increased in aged mice and depletion of MDSC by anti-Gr-1 antibody improved the anti-tumor immunity in aged mice.(15) In this study, the higher frequency of MDSC in aged mice confirmed the frequency of MDSC was increased

along with aging. While the function of MDSC was neutralized by entinostat (a class I-specific histone deacetylase inhibitor)(16), the survival of allogeneic skin grafts on aged mice was shortened and similar to the survival on young mice. This reflected the immunologic suppression of MDSC in aged mice.

The proliferating capacities of T-cells were decreased in aged mice. According to the results in this study, the proliferation of T-cells from aged mice was lower than those from young mice when the T-cells were stimulated by allogeneic dendritic cells. In Shen's study, they adoptively transferred young naïve T-cells to aged and young mice and found that the expansion of T-cells was reduced in the microenvironment of aged mice, and T-cell response to allo-transplantation in vivo was also impaired.(9) They concluded that T-cell immunity was impaired by intrinsic and extrinsic factors. Yager et al reported that the repertoire diversity in T-cells was declined in aged mice, which impaired CD8 + T-cells response to known immune-dominant epitopes.(11) Thus, proliferating ability of T-cells of aged mice was reduced and the reduction of T-cells was related to T-cells themselves and environmental factors.

Cytokine profile is one of the environmental factors in aged and young mice. Thus, a panel of cytokines in the serum were measured for aged and young mice. The results showed that the levels of TGF- $\beta$  in the serum of aged mice were significantly higher than that in young mice. TGF- $\beta$  is a multi-functional cytokine with the property of immunosuppression. In the microenvironment with a high level of TGF- $\beta$ , dendritic cells express low levels of co-stimulatory molecules and decrease the stimulatory capacity on T-cells.(17, 18) Naïve T-cells exposed in a high level of TGF- $\beta$  will be induced to become regulatory T-cells.(19, 20) In this study, we also found that T-cell proliferation capacity were lower in indirect antigen-presenting pathway when they were stimulated by dendritic cells coming from aged mice compared to young mice. All these results implied that immune cells were suppressed in aged mice which had high serum levels of TGF- $\beta$ .

Although the phenotypic population of CD4<sup>+</sup> and CD8<sup>+</sup> T-cells were not altered in aged mice, the cytotoxic abilities of T-cell coming from aged mice were lower than those coming from young mice. In vitro study, the results clearly showed that antigen-specific cytotoxicity of aged T-cells was significant lower than young T-cells. In vivo study, skin allografts survived longer in aged recipients than in young recipients. In a model of mice implanted with tumors, Grizzle et al demonstrated that T-cell cytotoxicity to tumor cells was decreased in aged mice and the tumor implanted in aged mice grew more rapidly than in young mice.(21) They also found that the decline of T-cell cytotoxicity was correlated to accumulation of myeloid-derived suppressor cells. Clearly, T-cell immunity declined along with aging and led to prolong skin graft survival in aged mice.

Regulatory T-cells could be induced in aged mice although native Treg was not different between aged and young mice. Treg is an important cells to modulate immune reactions in the hosts.(22) In organ transplantation, Treg is believed to induce infectious tolerance.(23, 24) Currently, ex vivo expansion of Treg has been applied to induce tolerance in clinical trials.(25) In this study, Treg was easier to be induced from T-cells derived from aged mice than from young mice. The true mechanism was not known. However, the higher serum level of TGF- $\beta$  in aged mice may prime the property of Treg and contributed to

following induction. It was reported that TGF- $\beta$  played a critical role of Treg development in thymus, but also could induce Treg in peripheral.(19) The higher level of TGF- $\beta$  implied that T-cell-mediated immunity could be suppressed easier in aged mice than in young mice and the grafts survival was prolonged.

## Conclusion

The allogeneic immunity was lower in aged than in young mice evidenced by a higher frequency of MDSC, higher serum level of TGF- $\beta$ , decreased function of T-cells, and easy-to-induced regulatory T-cells in aged mice. Blocking the function of MDSC by entinostat reversed the low immunity in aged mice and cause skin allograft rejection similar to young recipients. Taking together, the cellular immunity is weaker in aged mice than in young mice and MDSC plays the important role. Based on these experimental results, the clinical regimen of immunosuppression induction after transplantation for aged recipients should be adjusted to prevent or decrease adverse effects.

## Materials And Methods

Mice. Male C3H (H-2<sup>k</sup>, I-A<sup>k</sup>) and C57BL/10J (B10; H-2<sup>b</sup>, I-A<sup>b</sup>) mice, 8 to 10-week-old were purchased from the Animal Laboratory of National Institute Taipei, Taiwan, and maintained in the pathogen-free facility of Chang-Gung Memorial Hospital. Some B10 mice were maintained to 12 months old to be employed as aged mice. Experimental use of these mice was approved by Animal Care Committee of Chang-Gung Memorial Hospital (No. 105-0293C).

Bone marrow-derived dendritic cells propagation. To propagate bone marrow-derived dendritic cells (DC), bone marrow cells were harvested from femurs and tibias of C3H or B10 mice, and cultured in 24-well plates ( $2 \times 10^6$  cells/well) in 1 ml of RPMI-1640 medium (Life Technologies, Gaithersburg, MD), supplemented with 4 ng/ml recombinated mouse GM-CSF (R&D Systems Inc. Minneapolis, MN) and 1000u/ml mouse IL-4 (R&D Systems Inc. Minneapolis, MN). The propagation of large numbers of DC from mouse bone marrow with minor modification herein was similar to that described initially by Inaba et al.(26) The DC progenitor clusters were selected after 2 days of culture by gently swirling the plates and depleting the non-adherent granulocytes. Half of the cultural medium was refreshed. The DC was harvested after 5 days of culture.

Enriched T-cells. Enriched T-cells were obtained from splenocytes passing through nylon wool column. Nylon wool column was prepared by packing 0.5 gram nylon wool in a 10-c.c. syringe. The column was equilibrated by running cultural medium and incubated at 37°C for an hour before splenocytes were loaded into nylon wool column. Splenocyte-loaded nylon wool column was incubated at 37°C for one hour. Then, the non-adherent cells, enriched T-cells, were collected.

Cell lines. Murine cancer cell lines were employed in in vitro studies. R1.1, P815, Yac-1 cell lines were obtained from the Cell Collection and Research Center (CCRC, Hsin-Chu, Taiwan), maintained in antibiotic-

free Dulbecco's minimal essential Medium (DMEM, Life Technologies, Gaithersburg, MD) and supplemented with 10% v/v fetal bovine serum.

Phenotypes of immune cells. The phenotypes of the cells were classified by the expression of surface molecules. After the surface molecules were stained directly by a panel of fluorescenced monoclonal antibodies, the cell surface molecular expressions of DC, myeloid-derived suppressor cells (MDSC) and regulatory T-cells (Treg) were analyzed by cytofluorography employing a Beckman Coulter NAVIOS flow cytometer (Beckman Coulter Co., Indianapolis, IN).

Quantitative T-cell proliferation. The allogeneic stimulatory capacities of DC were determined via an one-way mixed lymphocyte reaction (MLR) employing colorimetric tetrazolium (MTT) assay.(27, 28) Enriched T-cells were stimulated by irradiated DC triplicatedly in 96-well plates for 3 days. In the last 4 hours of the procedure, sterilized MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide) (5 mg/ml, Sigma, St Louis, MO) was added to each well (10 ul/well) to produce blue formazan. Upon termination of MLR, acid-isopropanol (0.04N HCL-isopropanol, 100 ul/well) was added to each well and mixed thoroughly to dissolve the blue crystals. After 10 minutes at room temperature to ensure that all crystals were dissolved, the plates were read on a Dynatech MR580, microelisa reader, employing a test wavelength of 570 nm to measure the optical densities (OD) of formazan formation.

Cell-mediated cytotoxicity. T-cells activated by DC for three days were applied as effector cells. P815 (H-2<sup>d</sup>), R1.1 (H-2<sup>k</sup>), and YAC-1 (natural killer sensitivity) cells were applied as targets. Cell-mediated cytotoxicity was performed at various effector-to-target ratio triplicatedly in 96-well plates, and assessed by flow cytometry. To assess the cell-mediated cytotoxicity by flow cytometry, the targets were labeled with PKH-26 and 5-(and-6)-carboxyfluorescein diacetate succinimidyl ester (CFSE) according to the manufacturer's instruction (Sigma. St. Louis, MO). Briefly, target cells,  $1 \times 10^6$ /ml, were stained with PKH-26 (final concentration of  $2.5 \times 10^{-6}$  M) at room temperature for 5 minutes and washed by PBS once. Then, these PKH-26 labeled target cells were stained with CFSE (final concentration of  $5 \times 10^{-6}$  M). After 4 hours of cytotoxic reaction, all cells were collected and analyzed by flow cytometry. The target cells were identified by PKH-26 positive gate. The cells contained within the PKH-26 and CFSE<sup>high</sup> double positive gate represent viable target cells. Therefore, percent survival of target cells = (CFSE<sup>high</sup> percent of test well / CFSE<sup>high</sup> percent of spontaneous release) x 100%. Percent specific cytotoxicity= (1-% survival) x100%.

Cytokine measurement. The serum of young and old mice was collected. The product of cytokines was measured by enzyme-linked immunoabsorbent assay. The procedure was conducted as the instructions of producers. (PharMingen, San Diego, CA).

Skin transplantation. Under adequate anesthesia, an incision was made on the flank of B10 mice. A 1 x 1 cm skin flap taken from C3H mice was attached to the flank of B10 mice and fixed to adjacent skin with 3 - 0 Dexon sutures. The skin flap was protected by circulated gauge for 3 days. The skin flap were observed very 2-3 days. Rejection was diagnosed when the skin grafts were fully detached.

Statistical analysis. Unpaired Student's t-test was used to analyze continuous variables. Categorical variables were analyzed by either Chi-square test or Fisher's exact test. All pairwise multiple comparisons were done by Holm-Sidak method. The survival rates were calculated using the Kaplan-Meier method. The statistical analyses were all performed with SigmaPlot 12.3 for Window software (Systat Software, Inc., San Jose, CA, USA).  $P < 0.05$  was considered statistically significant.

## Declarations

**Ethics approval:** Experimental use of these mice was approved by Animal Care Committee of Chang-Gung Memorial Hospital (No. 105-0293C).

**Consent for publication:** not applicable.

**Availability of data and materials:** All data generated or analysed during this study are included in this published article

**Competing interests:** There is no conflict of interest among the authors.

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### **Author contribution:**

WCL designed the experiments and was the major contributor in writing the manuscript. YCW analyzed and interpreted the experimental data. HYH and PYH performed the in vitro experiments. CHC and CFL performed skin graft transplantation and interpreted the experimental data. All authors read and approved the final manuscript.

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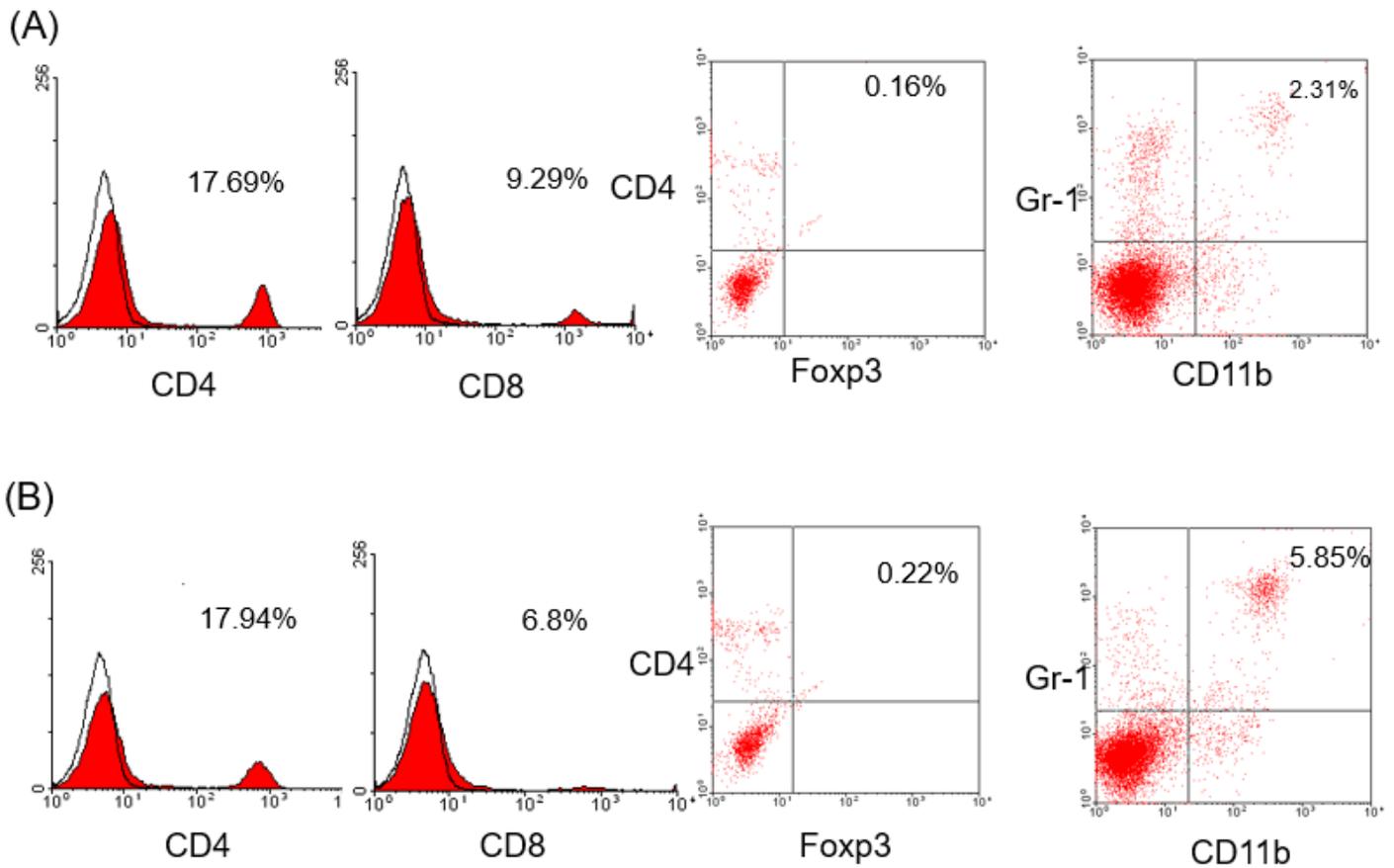
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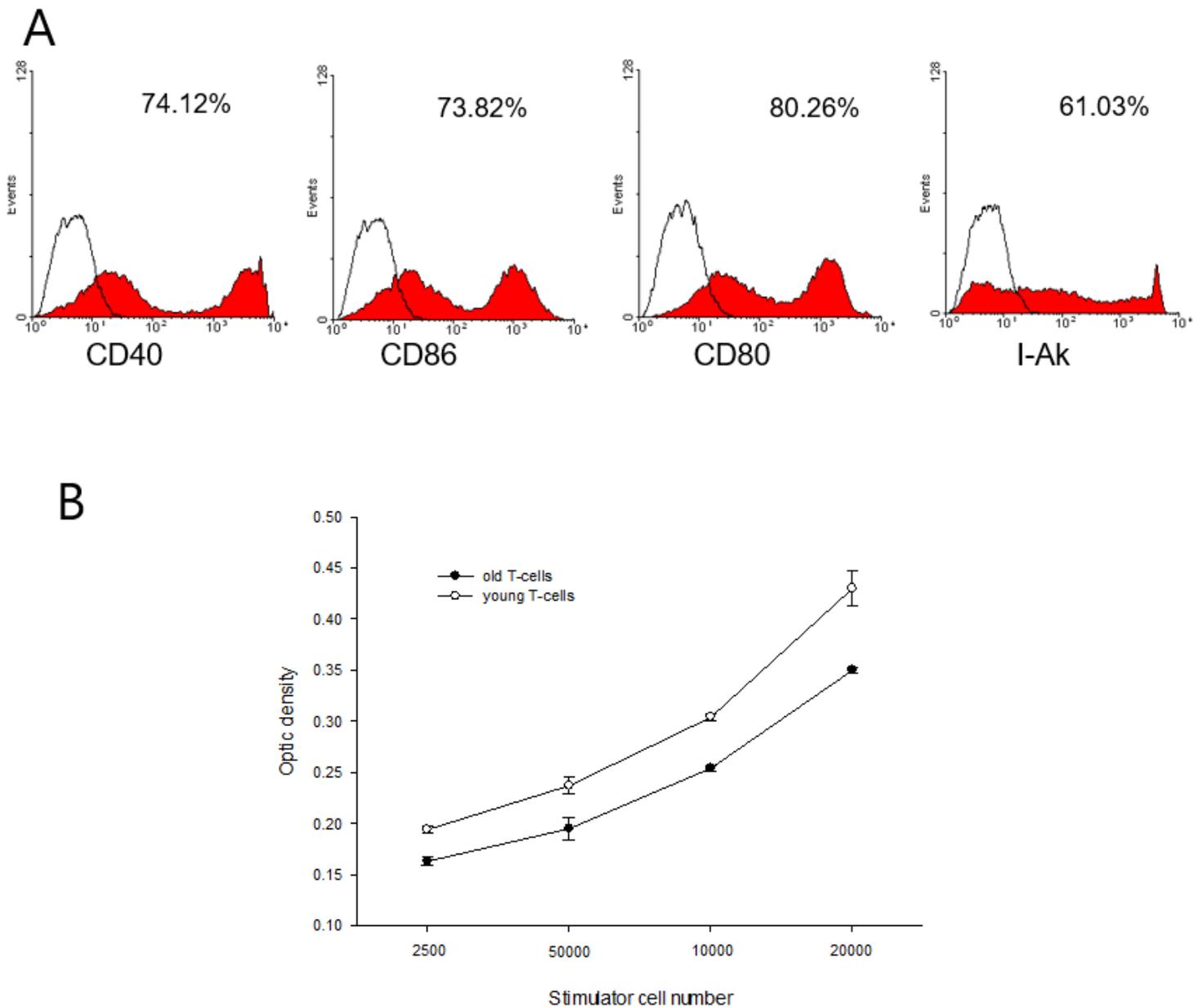
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## Figures



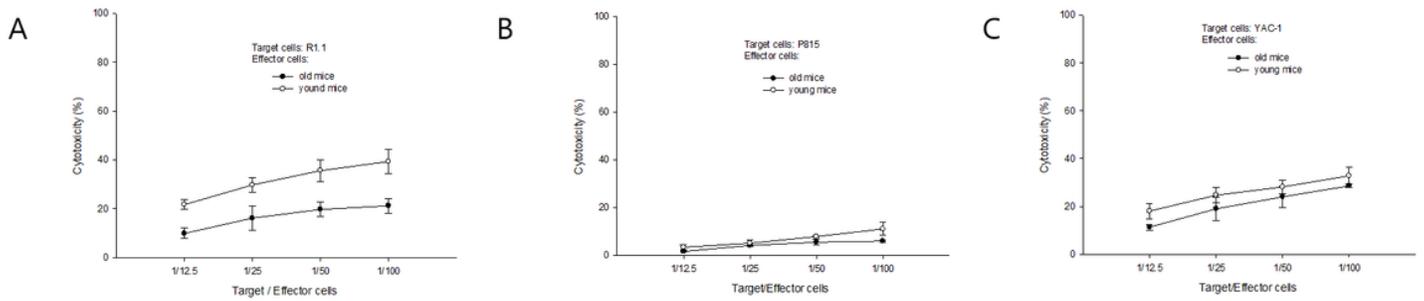
**Figure 1**

A representative of CD4+, CD8+, regulatory T-cells (CD4+foxp3+), and MDSC (CD11b+Gr-1+) in young (A) and aged (B) mice. The frequency of CD4+ ( $16.5 \pm 1.2\%$  versus  $14.6 \pm 2.9\%$ ,  $p = 0.185$ ), CD8+ ( $8.9 \pm 0.7\%$  versus  $8.4 \pm 1.6\%$ ,  $p = 0.324$ ), native regulatory T-cells ( $1.0 \pm 0.8\%$  versus  $0.4 \pm 0.6\%$ ,  $p = 0.160$ ) in aged and young mice was not different. However, the frequency of MDSC (CD11b+Gr-1+) in aged mice was higher than that in young mice ( $4.4 \pm 1.4\%$  versus  $1.6 \pm 1.1\%$ ,  $p = 0.026$ ).



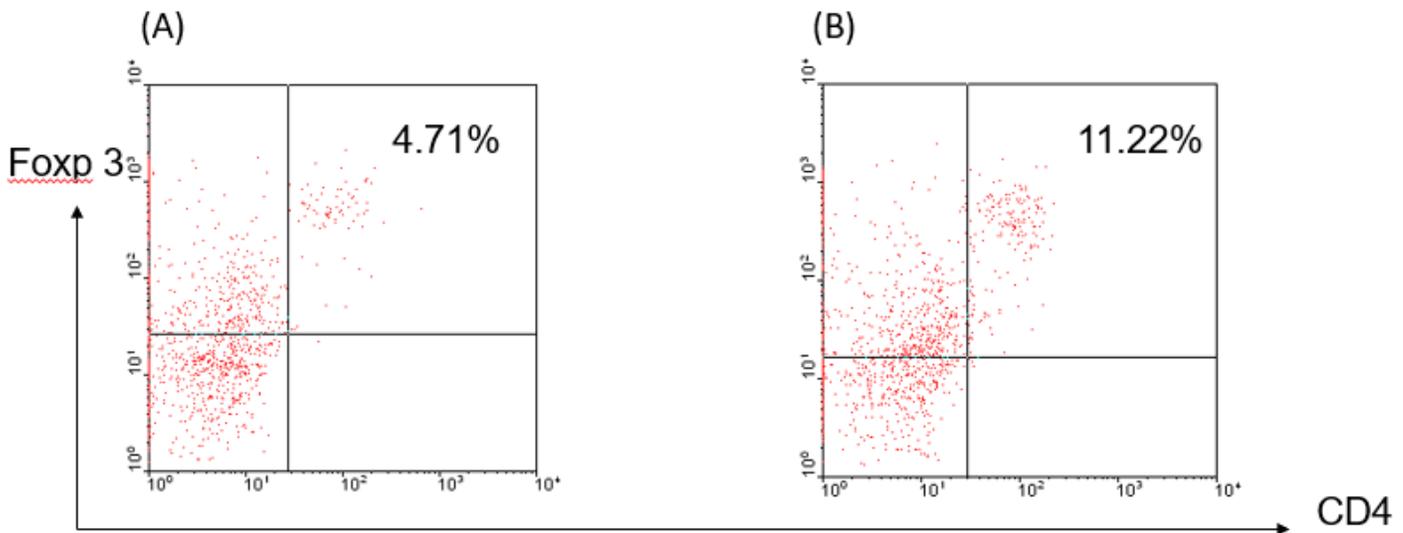
**Figure 2**

A representative of C3H mature DC and mixed lymphocyte reactions. (a) The C3H DC cultured in GM-CSF and IL-4 expressed mature phenotype with high levels of CD40, CD80, CD86 and I-Ak. (b) When this mature C3H DC was applied to activate enriched T-cells derived from aged or young B10 mice, MLR showed that proliferation capacity of T-cells from aged mice was lower than that of T-cells from young mice ( $0.350 \pm 0.003$  O.D. versus  $0.430 \pm 0.017$  O.D. at responders/stimulatory cells = 100/1,  $p = 0.001$ ).



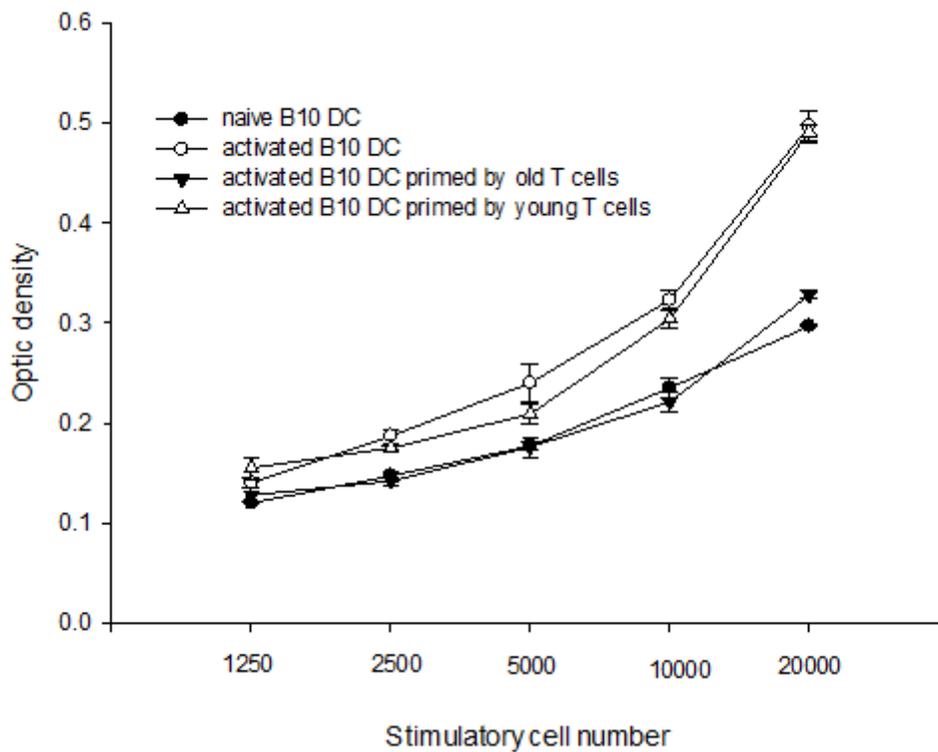
**Figure 3**

A representative of cytotoxic tests. (a) When R1.1 cells (H-2k, allogeneic) were used as target cells, T-cells derived from aged mice had a lower Ag-specific cytotoxic ability than T-cells derived from young mice ( $21.2 \pm 3.0\%$  versus  $39.3 \pm 4.8\%$  at target cell/effector cells = 1/100,  $p=0.003$ ). (b) When p815 cells (H-2d, third party) were used as target cells, T-cells derived from aged mice had a lower cytotoxic ability than T-cells derived from young mice ( $6.0 \pm 0.6\%$  versus  $11.0 \pm 2.7\%$  at target cell/effector cells = 1/100,  $p=0.017$ ). (c) When Yac-1 cells (non-Ag-specific, nature killer-sensitive) were used as target cells, the cytotoxic ability of T-cells derived from aged or young mice were not different ( $28.6 \pm 0.6\%$  versus  $32.8 \pm 3.5\%$  at target cell/effector cells = 1/100,  $p=0.100$ ).



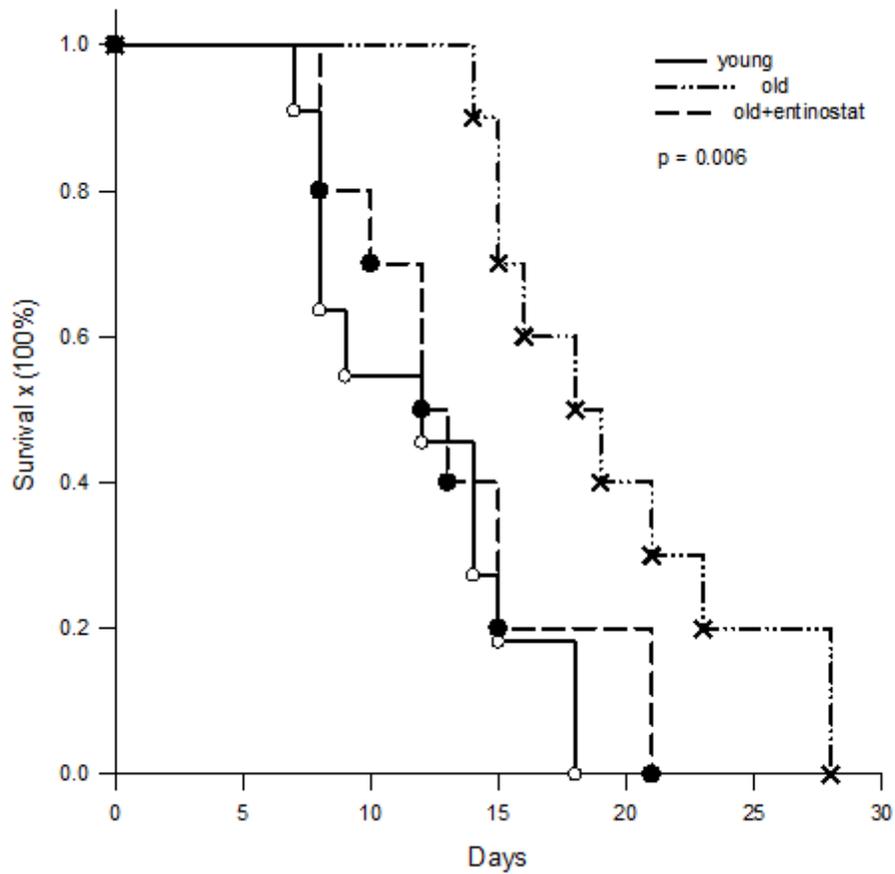
**Figure 4**

A representative of induced regulatory T-cells. Enriched T-cells derived from aged and young B10 mice were activated by C3H DC for 3 days, a higher frequency of CD4<sup>+</sup>foxp3<sup>+</sup> regulatory cells was induced in the T-cells derived from aged mice than young mice ( $7.87 \pm 3.42\%$  versus  $5.04 \pm 2.71\%$ ,  $p=0.023$ ).



**Figure 5**

A representative mixed lymphocyte reaction of indirect antigen presentation. B10 DC was pulsed with C3H splenocyte lysate overnight and used as stimulators to activate B10 enriched T-cells. The result showed that the proliferating capacities of T-cells from aged were lower than those of T-cells from young mice ( $0.328 \pm 0.004$  O.D. versus  $0.491 \pm 0.008$  O.D. at responders/stimulatory cells = 100/1,  $p = 0.001$ ).



**Figure 6**

Kaplan-Meier survival curve of skin allografts. Skin grafts from C3H mice were transplanted to young (n=11) B10 mice, aged B10 mice (n=10) and aged B10 mice (n=10) fed with entinostat. The results showed that the skin allograft survival on young B10 mice was  $11.9 \pm 5.2$  days and was prolonged to  $19.7 \pm 5.2$  days on aged mice ( $p = 0.005$ ). When the aged mice was fed with entinostat to inhibit MDSC, the survival of skin grafts was shortened to  $13.5 \pm 4.7$  days, which was not different from the survival on young mice ( $p = 0.359$ ).