New Approach 1

G-001 Transcutaneous Energy Transmission System for a Capsule Endoscope—Improvement of the Magnetic Field Distribution using array of small flat type primary coils—

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Background: In order to ease the pains on diagnosing the digestive system, it is effective that a capsule endoscope is used instead of conventional endoscope. We investigated to improve the energy transmission characteristics and detect the position of the capsule with a secondary coil in the digestive system, using the array consisting of the primary coils to transcutaneously transmit the energy to the capsule. In this paper, the array consisting of small flat type primary coils was made on an experimental basis, and the improvement of the magnetic field distribution by using the array was investigated.

Methods: The small flat type coils with a diameter of 10 cm, and the large flat type coil with a diameter of 30 cm were used for the primary coil, respectively. Nine small flat type coils connected in series were arrayed on a same plane. Under the two conditions by using the large flat type coil and using the array, respectively, the magnetic field distributions were evaluated and compared.

Results: At a height of 15 cm from the center of primary coil, the magnetic field strength in case using the nine small flat type coils was reduced by about 0.5 A/m compared with the strength in case using the large flat type coil. Therefore, improving the field distribution was tried by filling the aperture between the small flat type coils with smaller flat type coils. As a result, the magnetic field distribution and the energy transmission characteristics were improved.

G-002 BIOLOGICAL SAFETY OF PHOTOELECTRIC DYE-COUPLED POLYETHYLENE FILMS AS PROTOTYPES OF OKAYAMA UNIVERSITY-TYPE RETINOTHESES

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Background/Aim: We designed a new type of retinal prostheses: polyethylene films coupled with photoelectric dyes which absorb light and convert photon energy to electric potentials. We tested the safety of the photoelectric dye in cell culture and also implanted the prototypes in rat eyes.

Methods: The 12-day chick embryonic retinal cells were cultured for 2 days under dark or 8 hours daily light exposure with a photoelectric dye, 2-[4-[4-(dibutylamino)phenyl]ethenyl]-3-carboxymethylbenzothiazolium bromide, and cells were stained for dead and live cells. The retinal pigment epithelial cells were incubated with the dye for 4 hours and cell membrane permeability was tested by lactate dehydrogenase leakage. The two prototypes, original dye-coupled polyethylene film and dye-coupled recrystallized film, as well as the plain polyethylene film as a control, were implanted into subretinal space of Wistar rat eyes and examined histologically one week and one month after the implantation.

Results: Retinal cell growth was not influenced by the dye and only a few retinal cells were dead: the number of dead cells was significantly higher with a smaller concentration of the dye. Percent cytotoxicity of retinal pigment epithelial cells was not influenced by the dye. In rat eyes with the prototypes, tissue damage was negligible with few apoptotic cells and no inflammatory cells. GFAP up-regulated at the site of film implantation and glial encirclement of the films did not exceed 50% of the film circumference.

Conclusion: The photoelectric dye showed no cytotoxicity or rather had cytoprotective effects, and the prototypes induced no marked tissue reaction.

G-003 CAPABILITY AND IN VIVO EVALUATION OF VASCULAR STENT COATED WITH HIGHLY DISPERSED AND CALCINED HYDROXYPATITE NANOCRYS'TALS

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Background: Some types of vascular stent exist for stenosis of vascular in many clinical areas. Many developed stents are studied to inhibit complications such as restenosis. Recently, drug-eluting stent (DES) is mainly studied to prevent restenosis of vascular wall. However, DES also has some complications such as thrombus formation associated with stents and restenosis in long term clinical results so far.

Aim: This study is to determine of capability and biocompatibility of our novel vascular stent coated with calcined hydroxyapatite (HAp) nanocrystals. A previous study showed good biocompatibility of vascular stent coated with an amorphous HAp. However, the stent has characters of high decomposition, absorbable and weak binding between original stent and HAp. In the present work, we developed the novel vascular stent coated with highly crystallized HAp nanoparticles.

Methods: Calcined HAp nanocrystals were coated by using the array of small flat type primary coils, which was chemically modified by the graft polymerization of methacryloyloxypropyltrimethoxysilane (MTMS). These stents were implanted in femoral and common carotid arteries of dogs. Each right side was implanted control stents, and each left side was implanted HAp coated stents. Furthermore, the stent coated with HAp was preserved sirolimus, which were also implanted the same as procedure. These results were evaluated HE stain.

Results: The stents coated with HAp prompts early remodeling of vascular wall, less inflammatory reaction than the controls. In addition, our DES also has less hyper trophy vascular wall.

Summary/Conclusion: It was expected to improve restenosis and occlusion of vascular stent because biomaterial coated HAp has biocompatibility.

G-004 Novel strategy for in vivo MRI imaging of transplanted autologous cells

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Background: Recently, there has been an increasing interest in developing the cell transplantations therapy. However, the fate and functionality of the transplanted cells were not clarified yet. It is then necessary to develop a new safe technology to track the transplanted cells using the noninvasive imaging system for a long period of time. To this end, we selected magnetic resonance imaging (MRI) because MRI has been proven to be a particularly powerful tool for visualizing the tissues in a high resolution.

In this study, we have synthesized new contrast agents for cell tracking and detected the cells in vivo using MRI.

Results: Novel contrast agents for labeling the targeted cells were synthesized by conjugating Gd to poly (vinyl alcohol) (PVA). The relaxivity of these PVA-Gd conjugates was slightly higher than that of magnetite, which is typically used imaging agent. The intracellular behaviors of these PVA-Gd conjugates were examined by using FITC labeled PVA-Gd. In this case, not only the viability but also the proliferation rates of cells were not affected by the intracellular delivery of PVA-Gd. Furthermore, these PVA-Gd conjugates were retained stably in the cytoplasmic compartment up to 10 days. In addition, the in vivo imaging by using MRI was achieved.

Conclusion: PVA-Gd conjugates are synthesized and evaluated as MRI contrast agents. These PVA-Gd conjugates have high value as novel contrast agents for cell labeling. These results suggested that the ability of these PVA-Gd conjugates to be employed in the study of biological phenomena using MRI.
G-005 Structural Engineering Design for a sophisticated artificial myocardium using shape memory alloy fiber

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Aim: The authors have been developing a sophisticated artificial myocardium using shape memory alloy fiber, which is capable of supporting natural contractile function from the outside of the ventricle. As heart failure involves the decrease in myocardial contractile function, the direct mechanical assistance ratio would be effective. To improve its controllability and also the contractility assistance ratio, we refined the design of the myocardium from structural engineering viewpoint.

Materials and Methods: Prior to the establishment of the new design, the myocardial layered structure was obtained by MDCT or MRI. And we focused on the several points as follows: (1) Design improvement of artificial myocardial band to form contractile angle from the apex to aorta in an oblique direction. (2) Development of displacement amplification mechanism based on structural engineering in order to increase a contractile functional margin. Then we evaluated its mechanism in a mock circulatory system.

Result and Conclusion: Two prototype models were successfully designed and constructed; a) an oblique-type which could be attached to the ventricular surface in an oblique direction, and b) an extensible-step ladder-shaped type which has a series of plastic hinges glued on the parallel linked shape memory alloy fiber. As a result, in the hydrodynamic test by using mock circulatory system with an originally-designed silicone left ventricle, the oblique-type and the ladder-type boosted the ventricular contractile volume by 30% and 15%, respectively. Therefore, it was suggested that the improvement of ejection fraction was achieved by the structural design change of the myocardial assist device.

G-006 IN SITU AND EX VIVO PERFUSION OF DONOR ORGANS

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Aim. The quality of donor organs is highly influenced by the lack of oxygen that occurs after cardiac arrest has taken place. To prevent ischemic injury, during organ procurement organs are flushed with 4-8 liters cold perfusion solution in situ, typically cooled and stored and transported on ice (4°C, Static Cold Storage). Topical cooling however, proves to be rather ineffective during organ dissection the cooling solution has to be removed from the abdominal or thoracic cavity, thus creating unstable cooling conditions in which the donor organ becomes warmed and more vulnerable to ischemia. We developed in-situ and ex-vivo machine perfusion (MP) techniques that reduce ischemia by restoring organ perfusion inside and outside the body by delivering oxygen and nutrients and remove the waste products continuously.

Methods. A small pump circuit was developed that consist of one or two Delta Stream mini centrifugal blood pumps (MEDOS, Germany), tubing, an oxygenator, an organ container (or two cannulas that can be connected to the circulatory system of the donor), pressure-, flow-, temperature sensors and a heat exchanger. The motor unit operates in a pulsatile or non-pulsatile mode, either under pressure or under flow controlled conditions. Based on this modular circuit we made two pump applications; a) An Extra-organ perfusion ex-vivo machine perfusion (MP) device that reduces ischemia by restoring organ perfusion inside and outside the body by delivering oxygen and nutrients and removing the waste products continuously. b) An Extra-organ Perfusion System (ECOPS) for in-situ MP and 2. an ex-vivo kidney and liver MP device. All systems were tested in animal experiments. In pig hearttransplantation experiments we compared kidneys that were cold stored (normothermia for 24 hours) with kidneys that were a) thermally machine perfused using low pressure (30/20 mmHg, n=5) and high pressure (60/40 mmHg, n=5), using UW-MP solution. Livers were 20 hours hypothermically dualy machine perfused ex-vivo (n=5) with UW-MP, as well as normothermically dualy MP for 4 hours (n=5) with blood, while the ECOPS was used in pigs to assess its cooling performance (UW-MP solution, n=4).

Results. a) In comparison to CS, low pressure perfused kidneys performed best (decreased creatmine, oxidative stress and tubular injury), followed by high pressure MP organs. However, the high pressure perfused kidneys showed extensive endothelial damage, which made us decide to choose for low pressure driver settings. After 20 hours hypothermic MP harvesting of the liver did not show signs of cell injury. However, the liver portal vein sinus showed some fibrosis, which could be hampered inflow of perfusion solution. In normothermic liver perfusion blood vessels remained in good condition while all livers functioned well post operative after 4 hours of MP.

Conclusion. The developed system allows the use of all kinds of perfusion solutions, varying from full blood to special non-cellular perfusate solutions. Several successful transplantation experiments have now proved the way for clinical application.

G-007 DEVELOPMENT OF A POINT OF CARE DEVICE FOR NON-INVASIVE MEASUREMENT OF ELECTROLYTES

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Background/Aim: Detection and quantification of electrolytes such as sodium, potassium, calcium, chloride, etc. is needed in the diagnosis and treatment of many health conditions. Currently, electrolyte measurement requires blood samples taken invasively. A non-invasive method utilizing optical technology for electrolyte measurement is being developed.

Methods: A testing apparatus was developed consisting of an electronic circuit, ultraviolet and infrared light emitters and photo-detectors, and a data acquisition system to record output voltage across the photodetectors. Infrared and ultraviolet light was transmitted through chemical concentrations of various molalities (1M, 5M and 10M) of potassium chloride (KCl) and potassium sulphate (K2SO4). For each concentration tested, output voltage from the photodetectors was recorded and analyzed.

Results: 1) As molality concentration increased for both potassium chloride and potassium sulphate, the photodetector output voltage decreased. 2) At higher concentrations, more light is absorbed by the potassium chloride and potassium sulphate resulting in less light received by photodetectors. 3) The sensitivity of ultraviolet light changes in molality concentration was more specific than that of infrared light.

Summary/Conclusion(s): 1) Concentrations of potassium ions may be detected and measured using infrared and ultraviolet light sources. 2) The combination of both infrared and ultraviolet light may provide a novel method for non-invasively predicting the concentration of potassium and other electrolytes. Further studies are required to determine optimal methods to implement these findings into a medical device for point of care testing of electrolytes.

G-008 Development of an electrochemical microvalve for chemical neuronal interface

Department of Applied Chemistry, Shizuoka Institute of Technology
Satoshii Akaite, Yano Yoshimi

Background: Our final purpose is development of an informational interface between neural system and electric circuit for artificial sense organs. We have developed an electrochemical micropump for rapid micro-administration of neurotransmitters toward neurons. This micropump enables real time control of neuronal signals.

Refilling system is needed for long-term use for the pump. The system needs rapid and micro-scale valve works, which is yet to be established. We fabricated on trial a microvalve in which electrolysis of water controls diaphragm in flow path.

Methods: The valve is composed from flow path, diaphragm, and electrochemical chamber. Polyethyleneimine (PEI) was applied for flow path and a diaphragm. The electrochemical chamber is filled with electrolyte solution and contains platinum electrode.

Results: Voltage application generated bubbles by water-electrolysis and deformed the diaphragm to close the path completely. After stopping the voltage application, bubbles disappeared by platinum catalysis and the flow path opened again. However, it takes several minutes for the close and the reopen of the path by the voltage change. It is too slow for controlling neuronal signals. We are trying optimal design of the valve to obtain rapid response.

Fig.: Mechanism of electrochemical microvalve (a) open (b) close.

G-009 Development of an electrochemical microvalve for chemical neuronal interface

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Satoshii Akaite, Yano Yoshimi

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