Reumatologia 2010; 48, 5: 317–319

The disposable incubator for tissue engineering

Inkubator jednorazowego zastosowania dla potrzeb inżynierii tkankowej

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Key words: tissue engineering, contamination, disposable.

Słowa kluczowe: inżynieria tkankowa, skażenie, jednorazowość.

Summary

To prevent the possibility of contamination of cultured cells from different patients we have designed the Disposable Incubator for Tissue Engineering in which the elements having direct contact with the cell culture, as well as all sensors, are disposable.

Streszczenie

W celu eliminacji możliwości zanieczyszczenia hodowli tkankowych skonstruowano aparaturę, w której zarówno wszystkie elementy, jak i sama przestrzeń bezpośrednio stykające się z hodowlami tkankowymi danego pacjenta są wyłącznie jednorazowego zastosowania.

Introduction

The achievements of regenerative medicine allow the design of grafts based on scaffolds and patients' own cells. Tissue engineering of chondrogenic grafts offers an attractive opportunity for replacement of degenerated cartilage or fusion of degenerated joints. Autologous transplantations of cell-based grafts seems to be a chance for regeneration of degenerated joints. In vitro manufacture of such implants is currently limited by the complex and expensive procedure and high risk of contamination. This study presents a safe and cost-effective incubator that allows an intraoperative approach to engineering cell-based cartilage grafts.

The recently published procedures and suggested standards for conditions required to transform cells into subsequently transplanted chondrocytes are not sufficiently safe when considering the aspects of tissue engineering [1,2]. Isolated cells, following incubation and transformation in the expected direction, are implemented back to the same patient (autotransplantation) although the risk of contamination between cells of different patients cultured in the same incubator is very high, especially when carefully controlled physical conditions (constantly lowered oxygen tension under modulated pressure) are necessary to recapitulate embryonic cartilage formation [3].

To prevent the possibility of contamination of cultured cells we have designed the Disposable Incubator for Tissue Engineering (DITE) in which the elements having direct contact with the cell culture, as well as all sensors and detectors, are disposable (Fig. 1).

Description of construction

The designed installation has three characteristic features. The first one is the ability to regulate oxygen

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Submitted: 22.09.2010

concentration; the second is the ability to control variable pressure value; and the third is safety – the section for incubation is fully disposable. DITE also lowers the costs of a single cultivation process without losing flexibility or precision. The modular build of the incubator allows much greater mobility and the possibility of further improvements of separate elements.

The installation has three main sections: 1) the non-disposable section of compound preparation, 2) the disposable section of the process chamber, 3) the computer system of control, measurement and archiving.

In the compound preparation (CP) section the proper composition of gases and the transportation of the gases to the process chamber under the proper pres-

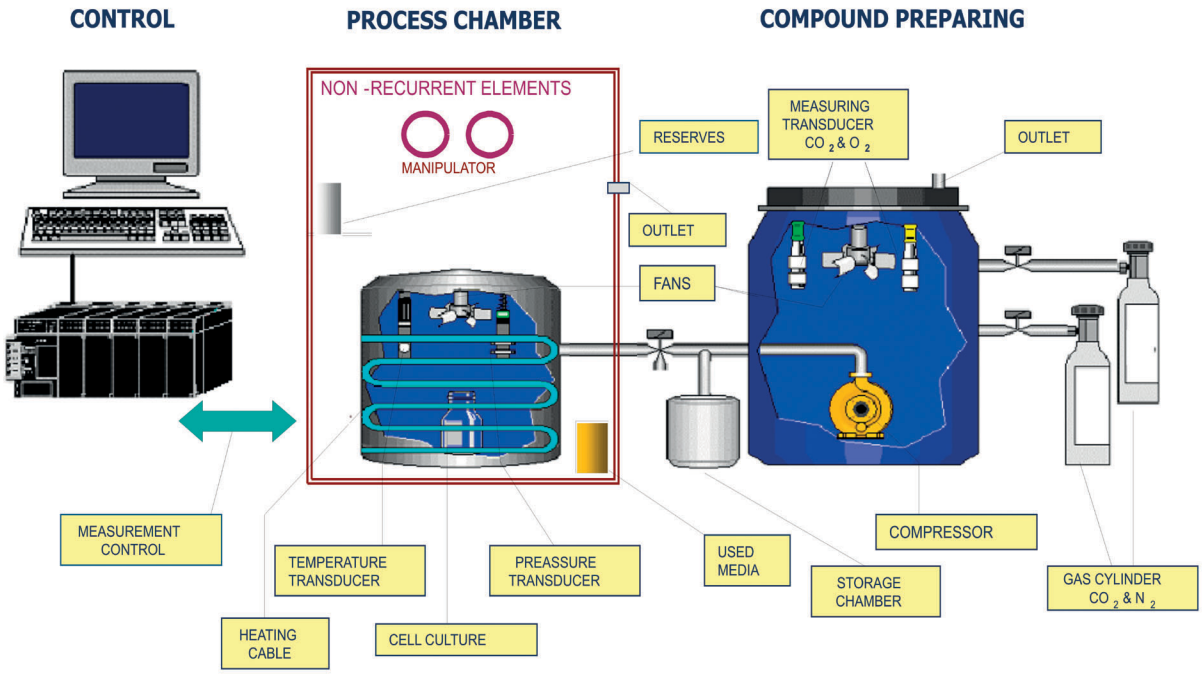

Fig. 1. The Disposable Incubator for Tissue Engineering (DITE).
The Compound Preparation section is a defined space in which preparation of reagents, solutions (in a laminar flow hood) and the proper composition of gases is carried out. Reagents, solutions and gases intended for contact with the tissue of a particular patient are transported, unidirectionally, from the Compound Preparation section to the Process Chamber. The Process Chamber (40 × 40 × 35 cm) is equipped with a laminar flow hood. This section is composed only of disposable elements. In this section manipulation and cultivation of cells is carried out. Reagents and solutions needed for cell cultivation are allocated to this section. The Computer Control section supervises physical parameters of the cultivation process. Wires and sensors having contact with the Process Chamber are fully disposable.

Ryc. 1. *Inkubator dla potrzeb inżynierii tkankowej jednorazowego zastosowania.*
Strefa Compound Preparing to zbiorcza nazwa przestrzeni, w której przygotowywane będą zarówno odczynniki do hodowli tkankowych (w komorze laminarnej), jak i odpowiednie mieszaniny gazów. Z tej przestrzeni, zarówno gazy, jak i odczynniki przeznaczone do kontaktu z komórkami danego pacjenta, będą się przemieszczać jedynie jednostronnie do strefy Process Chamber. Strefa Process Chamber (40 × 40 × 35 cm) będzie znajdować się w obrębie komory laminarnej. Strefa ta składa się jedynie z elementów bezzwrotnych (non-recurrent elements), w jej obrębie dokonywać się będzie wszelkich manipulacji z hodowanymi komórkami. Odczynniki stosowane aktualnie lub w przyszłości będą znajdować się już w tej sekcji. Strefa Control to przestrzeń monitorowania. Wszelkie końcówki przewodów, mających kontakt z przestrzenią znad hodowli komórkowych, również będą jednorazowego zastosowania.

sure value are carried out. The system of preparation of atmospheric composition is in the form of a chamber containing gas-measuring transducers and air fans. The gases are mixed in adjusted proportions and then transported through the compressor with the proper pressure to the process chamber. Gas containers located outside the chamber deliver oxygen, nitrogen and carbon dioxide gases. Between the compound preparation and process chamber a flexible storage chamber is located which increases the stability of the whole system. Outlet of gas from the CP is controlled by an electric valve. A biological filter separates the disposable and the non-disposable sections, preventing air mixing. Behind the valve the air flow is one directional, reducing the risk of the biological material being contaminated during cultivation.

The second component of the device is the process chamber (PCH – the only part having contact with the biological material), in which the cultivation process is maintained. All elements of this part of the system are disposable and will be replaced after each patient. The PCH consists of a sterile manipulator and a disposable pressure chamber with a test tube containing the cell culture. The other elements of this component include an electric heating cable, an air fan, and the pressure and temperature transducers. Leftover gases are evacuated unidirectionally through the outlet to the surroundings. To maintain the required temperature, depending on the environmental conditions, it may be possible to use an additional cooling system.

The computer control (CC) is the part of the system which unites the whole device. Here the cultivation process is controlled and all parameters (value and duration of pressure, temperature, composition of gases) can be adjusted to the requirements. All obtained data can be visualized, analysed and then stored on hard disks.

Summary

One of the biggest limitations on the introduction of autologous cell-based grafts in treatment is safety of manufacturing them and organization of intraoperative tissue engineering. The concept of the Disposable Incubator for Tissue Engineering allows the main limitations to be overcome. The disposability of all elements which have contact with the culture increases the safety of the incubator; the modular build makes it easier to transport and to improve; the low-cost disposable elements make it cheaper; and the computer control makes it much more precise, flexible and user-friendly. The cost of disposable elements which need to be replaced after each patient is estimated at about 50-100 Euro. The previous, preliminary version of the system has already been successfully used in the Department of Biochemistry of the Institute of Rheumatology in Warsaw, Poland.

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