

Influence of ELF Magnetic Field on Anticancer Drug Cisplatin Potency

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Influence of ELF Magnetic Fields on Anticancer Drug Cisplatin Potency

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Anticancer drugs are generally used during cancer chemotherapy. However, when the anticancer drug is administered, it is effective to not only cancer cells of an affected part but also normal cells of a whole body, and, as a result, side effects occur. Therefore if ELF magnetic fields exposure enhances the potency of anticancer drug, dosage of the drug can be reduced, and, as a result, the side effects can be suppressed. In this study, it was evaluated whether ELF magnetic fields exposure cause alterations in the potency of anticancer drug, cisplatin. It was found that the potency of cisplatin with ELF magnetic fields was higher than the potency of cisplatin only.

Key Words: ELF magnetic fields, anticancer drug, cisplatin, *Escherichia coli* (*E. coli*)

1. Introduction

It has been reported that magnetic fields exposure can alter the biological effect of chemical substance [1-4]. MitomycinC (MMC) is a kind of anticancer drug. Extremely low frequency (ELF) magnetic fields exposure enhances the potency of MMC against *Escherichia coli* (*E. coli*) bacterium cells [5].

Anticancer drugs are generally used during cancer chemotherapy. However, when the anticancer drug is administered it is effective to not only cancer cells of an affected part, but also normal cells of a whole body, and as a result various side effects occur. Therefore if ELF magnetic fields exposure enhances the potency of anticancer drug, dosage of the drug can be reduced without weakening the potency of anticancer drug at the affected part and then, the side effects can be suppressed.

The purpose of this study is to evaluate whether ELF magnetic fields exposure cause alterations in the potency of anticancer drug cisplatin.

2. Materials and Methods

2.1 ELF Magnetic Fields Generator

ELF Magnetic fields generator used in this study is shown in Fig. 1. The magnetic fields generator can generate sine wave alternating magnetic fields (60 Hz). B-V property and B-I property of ELF magnetic fields generator are shown in Fig. 2.

The CE-group (cisplatin and ELF magnetic fields exposure) cells were cultured in test tubes located in

the experimental area of ELF magnetic fields generator. The C-group (cisplatin exposure) cells were cultured in an incubator placed far from magnetic fields generator. There were 10 μT magnetic fields in C-group incubator, but the magnetic fields were vanishingly small compared to the magnetic fields by generator. Therefore, the magnetic fields in C-group incubator are no problem.

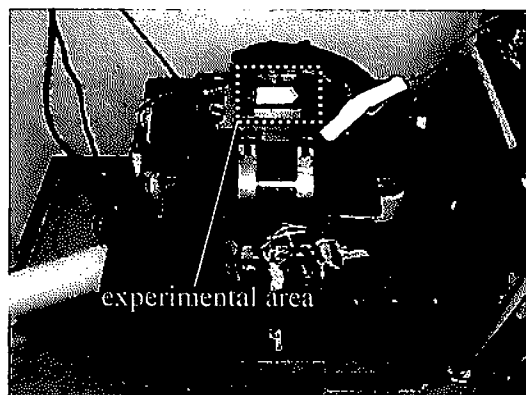


Fig. 1 ELF magnetic fields generator

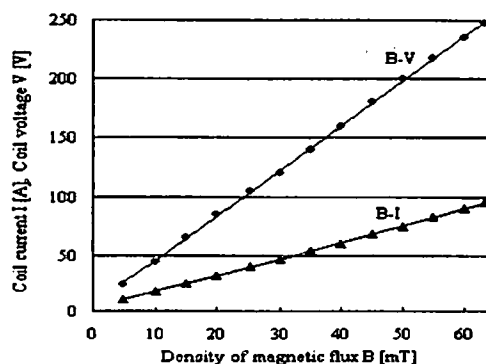


Fig. 2 B-V property and B-I property of ELF magnetic fields generator

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2.2 Cisplatin

Cisplatin widely used anticancer drugs, obstructs deoxyribonucleic acid (DNA) replication by binding on the DNA and suppresses the cell proliferation [6]. Cisplatin includes platinum. Because platinum is one of metals, ELF magnetic fields exposure may enhance the potency of cisplatin. Cisplatin hydrolyzed by H₂O bind covalently to a G base of DNA. In a similar way about other Cl, cisplatin bind covalently to other G base of DNA. As a result, cisplatin is cross-linked on single DNA strand, distorts the DNA, obstructs the DNA replication and inhibits proliferation of cell. As a result, cisplatin has anticancer effect.

2.3 *Escherichia coli* JE5595 *recA1*

Since cisplatin affects *E. coli* cells as well as human cells, *E. coli* cells were used in substitution for the human cells. Human cell growth cycle is one day and *E. coli* cell growth cycle is thirty minutes ($\times 2^{48}$ /day). Compared to human cell growth cycle, *E. coli* cell growth cycle is very short. So the experimental data was get quickly.

E. coli cell has repair functions against cellular damage. *E. coli* JE5595 *recA1* knocked out the repair gene was used to enhance DNA cross-link frequency by cisplatin.

2.4 Colony Assay

E. coli cells mixed with cisplatin (0, 2.5, 5, 7.5 $\mu\text{g/ml}$) were divided into C-group and CE-group. C-group cells were cultured at 36 °C where there were no added ELF magnetic fields. CE-group cells were cultured inside the ELF magnetic fields generator (60 Hz, 50 mT or 30 mT). After reaction time, the *E. coli* of C-group and CE-group were taken out, and they were plated on each solid medium. As shown in Fig. 4, colonies of *E. coli* were formed. The number of the colonies showed the number of *E. coli* cells, because one colony was formed from single bacterial cell. If there was fewer number of the *E. coli*, the effect of cisplatin would be higher. By comparing the *E. coli* cell number of C-group with the number of CE-group, it was evaluated whether ELF magnetic fields exposure cause alterations in the potency of cisplatin.

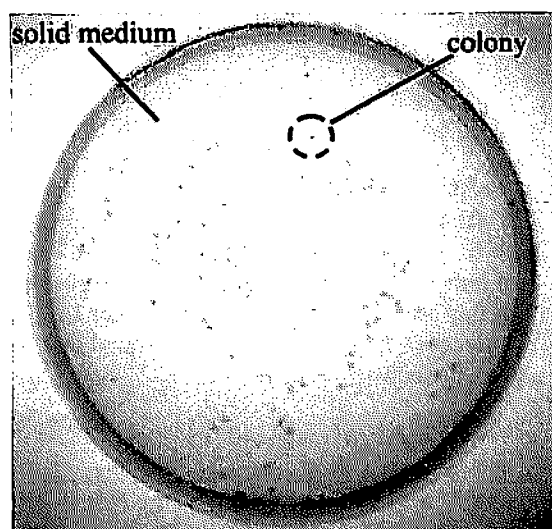


Fig. 3 C-group colonies on the solid medium

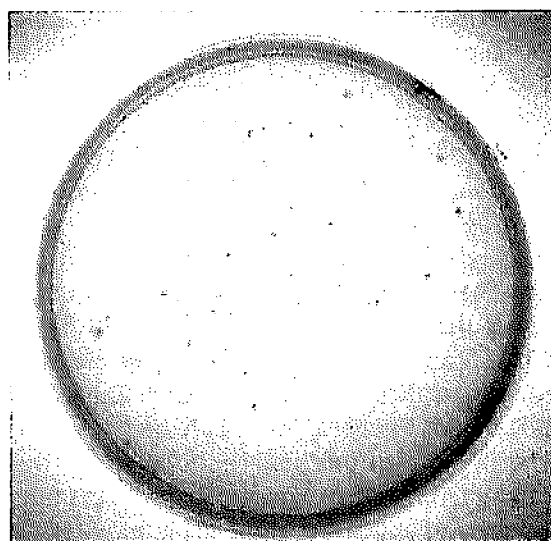


Fig. 4 CE-group colonies on the solid medium

3. Results

3.1 Influence of ELF Magnetic Fields (60 Hz, 50 and 30 mT) on the Potency of Cisplatin

Figure 6 shows the influence of ELF magnetic fields (60 Hz, 50 mT) on the potency of Cisplatin.

At cisplatin concentration 0 $\mu\text{g/ml}$, the *E. coli* cell number of CE-group was the same as the number of C-group *E. coli*. Therefore, *E. coli* cell growth was not influenced by ELF magnetic fields.

The *E. coli* cell number of 2.5 $\mu\text{g/ml}$ CE-group was similar to C-group for 6 h. ELF magnetic fields did not seem to affect potency of 2.5 $\mu\text{g/ml}$ cisplatin. However, at 24 h the *E. coli* cell number of CE-group was fewer than C-group.

At 5 $\mu\text{g/ml}$ cisplatin, viable cell number of CE-group was fewer than C-group after 2 h. The same observation at 24 h showed that the cell number of CE-group was much fewer than C-group.

At 7.5 $\mu\text{g/ml}$ cisplatin, influence of ELF magnetic fields was similar to the case of 5 $\mu\text{g/ml}$ cisplatin.

The potency of 2.5 $\mu\text{g/ml}$ cisplatin with ELF magnetic fields was lower than 5 $\mu\text{g/ml}$ cisplatin only for 6 h. But, at 24 h the potency of 2.5 $\mu\text{g/ml}$ cisplatin with ELF magnetic fields was higher than that of 5 $\mu\text{g/ml}$ cisplatin only.

The potency of 5 $\mu\text{g/ml}$ cisplatin with ELF magnetic fields was same level as 7.5 $\mu\text{g/ml}$ cisplatin only for 6 h. Further, at 24 h it was observed that the potency of 5 $\mu\text{g/ml}$ cisplatin with ELF magnetic fields was higher than 7.5 $\mu\text{g/ml}$ cisplatin only.

Figure 7 shows the influence of ELF magnetic fields (60 Hz, 30 mT) on the potency of Cisplatin. Influence of ELF magnetic fields was similar to the pattern of ELF magnetic fields (60 Hz, 50 mT).

These results indicate that the potency of cisplatin with ELF magnetic fields was found to be generally higher than the potency of cisplatin only.

4. Conclusion

It was observed that ELF magnetic fields (60 Hz, 50 and 30 mT) exposure enhance the cell-growth inhibitory property of cisplatin. By reaction time 24 h, the potency of cisplatin with ELF magnetic fields was much higher than that of cisplatin only. Further the potency of low concentration cisplatin with ELF magnetic fields was much higher than high concentration cisplatin only. These results indicate that dosage of the cisplatin can be reduced under ELF magnetic fields exposure.

The ELF magnetic fields used during experimentation were 30 and 50 mT. The results obtained for these magnetic flux densities were very similar. However, more experiments should be performed for a wider range of magnetic fields to find the best condition of magnetic fields.

Cisplatin has many steps (penetration into a cell, binding to DNA, etc.) to inhibit the growth of cancer cells. Currently it is not known which step the ELF magnetic fields affect. In future research must be performed to identify the step. And effectiveness of ELF magnetic fields exposure on the potency of cisplatin should be examined using human cells.

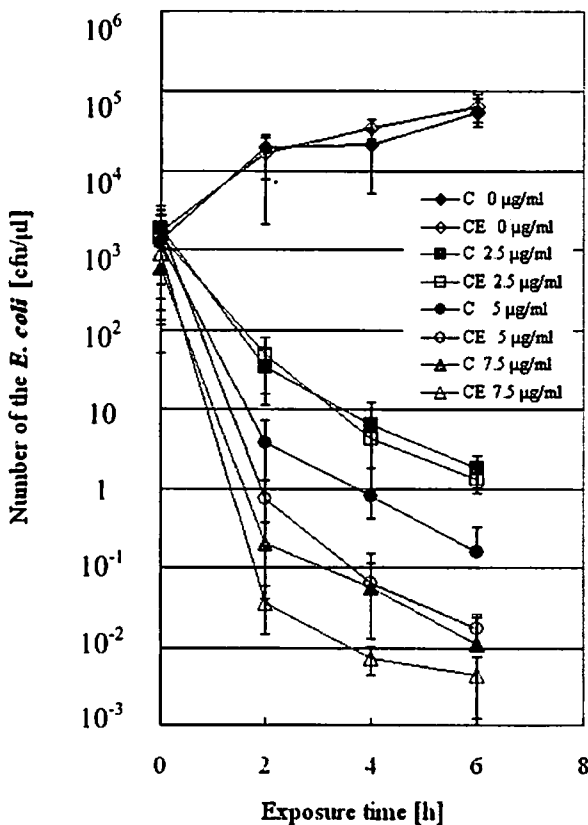


Fig. 5 Effect of ELF magnetic fields (60 Hz, 50 mT) on the potency of cisplatin

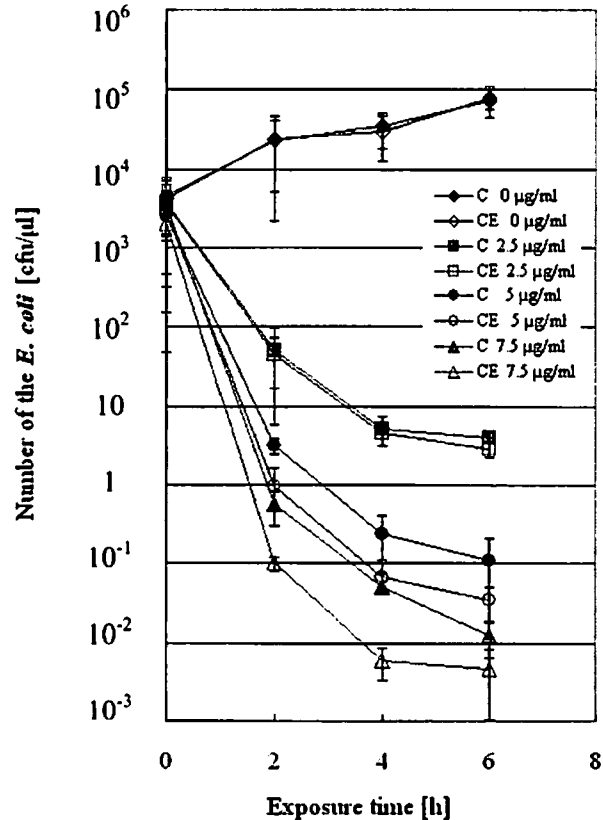


Fig. 5 Effect of ELF magnetic fields (60 Hz, 30 mT) on the potency of cisplatin

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