ON ANALYTICAL APPROACH FOR ANALYSIS OF DISSOLUTION OF A MEDICINAL PRODUCT IN AN ORGANISM

Evgeny L. Pankratov

Mathematical and Natural Sciences Department, Nizhny Novgorod State University, 23 Gagarin avenue, Nizhny Novgorod, 603950, Russia

ABSTRACT

In this paper we introduce a model of dissolution of a medicinal product in a organism with account of changing of conditions. The model gives a possibility to estimate spatio-temporal distribution of concentration of a medicinal product during dissolution. We also consider an analytical approach to analyze the above dissolution. We consider a possibility to accelerate and decelerate of the above dissolution.

KEYWORDS

Dissolution of a medicinal product; changing of speed of dissolution of a medicinal product; analytical approach for analysis.

1. INTRODUCTION

Currently quantity of new medicinal products are intensively increased [1-6]. At the same time existing medicinal products are improving [1-6]. Usually influence of a medicinal products on organism could be done experimentally. At the same time influence of a medicinal products on organism could be theoretically estimated. Also one can find another actual problem is speed of dissolution of a medicinal products in organism. In this paper we consider a model for estimation of distribution of concentration of a medicinal product in space and time. Based on the model we analyzed the above concentration with account possible changing of properties of organism.

2. METHOD OF SOLUTION

In this section we consider a model for estimation and analysis of dissolution of a medicinal product in an organism. To estimate the above distribution of concentration of the above product was estimated as a solution of the following second Fick's law [4,5]

$$\frac{\partial C(x,t)}{\partial t}=\frac{\partial}{\partial x}\left[D(x,T)\frac{\partial C(x,t)}{\partial x}\right]+\frac{S}{V\,h}D(x,T)\,C(x,t)\,N(x,t). \tag{1}$$

Function $C(x,t)$ describes distribution of concentration of the above product in space and time; function $D(x,T)$ describes the dependence of coefficient of diffusion of the considered product at different conditions of transport in position with coordinate x and at temperature T; S is the square of available for dissolution of solid surface; V is the volume of dissolution media; h is the width of the diffusion layer; function $N(x,t)$ describes distribution of concentration of other substances in organism in space and time. The considered other substances interacting with the infused medical product. Initial and boundary conditions for concentration of the considered medicinal product could be written in the following form

$$C(x,0)=f_C(x),\ \left.\frac{\partial C(x,t)}{\partial x}\right|_{x=0}=0,\ C(L,t)=0. \tag{2}$$

Next let us to solve the Eq. (1) with conditions (2) by method of averaging of function corrections [6-8]. First of all we transform Eq. (1) to the following integral form

$$C(x,t)=C(x,t)+\frac{1}{L^2}\left\{\int_0^t\int_0^x D(v,T)\,C(v,\tau)\,d\,v\,d\,\tau-\int_0^t\int_0^x (x-v)C(v,\tau)\frac{\partial D(v,T)}{\partial v}\,d\,v\,d\,\tau+\right.$$
$$+\frac{S}{V\,h}\int_0^t\int_0^x (x-v)\,D(v,T)C(v,\tau)N(v,\tau)\,d\,v\,d\,\tau-\int_0^t\int_0^L D(v,T)\,C(v,\tau)\,d\,v\,d\,\tau+\int_0^L (L-v)\,\times$$
$$\left.\times\,C(v,t)\,d\,v+\int_0^x (x-v)\,f(v)\,d\,v+\int_0^t\int_0^L (L-v)C(v,\tau)\frac{\partial D(v,T)}{\partial v}\,d\,v\,d\,\tau-\int_0^x (x-v)\,C(v,t)\,d\,v\right\}. \tag{3}$$

Now one shall substitute the not yet known average value of concentration of medical product α_1 instead of the concentration $C(x,t)$ in the right sides of the equation (3). After the operation we obtain the following relation for the first-order approximation of concentration of the above product

$$C_1(x,t)=\alpha_1+\frac{1}{L^2}\left[\int_0^x (x-v)\,f(v)\,d\,v+\frac{\alpha_1 S}{V\,h}\int_0^t\int_0^x (x-v)D\,(v,T)N(v,\tau)\,d\,v\,d\,\tau+\alpha_1\frac{L^2-x^2}{2}\right], \tag{4}$$

The average value α_1 was obtained by the classical formula [7-9]

$$\alpha_1=\frac{1}{L\Theta}\int_0^\Theta\int_0^L C_1(x,t)\,d\,x\,d\,t\,. \tag{5}$$

Substitution of relation (4) into relation (5) gives a possibility to obtain relation to determine average value α_1 in the final form

$$\alpha_1=V\,h\,\Theta\int_0^L \left(L^2-x^2\right)f(x)\,d\,x\Bigg/\left\{S\left[\int_0^\Theta(\Theta-t)\int_0^L\left(L^2-x^2\right)D(x,T)N(x,t)\,d\,x\,d\,t-\right.\right.$$
$$\left.\left.-2\int_0^\Theta(\Theta-t)\int_0^L x\,(L-x)D(x,T)N(x,t)\,d\,x\,d\,t\right]-\frac{2}{3}V\,h\,\Theta\,L^3\right\}. \tag{6}$$

The approximation of the function $C(x,t)$ with the next order was obtained in the framework of the classical algorithm of the method of averaging of function correction: one shall replace of the function $C(x,t)$ on the sum $C(x,t)\to\alpha_2+C_1(x,t)$ [7-9]. The replacement leads to the following relation for the required approximation

$$C_2(x,t)=\alpha_2+C_1(x,t)+\frac{1}{L^2}\left\{\int_0^t\int_0^x D(v,T)\,[\alpha_2+C_1(v,\tau)]\,d\,v\,d\,\tau-\int_0^t\int_0^x (x-v)[\alpha_2+C_1(v,\tau)]\frac{\partial D(v,T)}{\partial v}\,d\,v\,d\,\tau+\right.$$
$$+\int_0^x (x-v)\,f(v)\,d\,v+\frac{S}{Vh}\int_0^t\int_0^x (x-v)D(v,T)[\alpha_2+C_1(v,\tau)]N(v,\tau)\,d\,v\,d\,\tau+\int_0^L (L-v)\,[\alpha_2+C_1(v,t)]\,d\,v+$$
$$+\int_0^t\int_0^L (L-v)[\alpha_2+C_1(v,\tau)]\frac{\partial D(v,T)}{\partial v}\,d\,v\,d\,\tau-\int_0^x (x-v)\,[\alpha_2+C_1(v,t)]\,d\,v-\int_0^t\int_0^L\,[\alpha_2+C_1(v,\tau)]\,\times$$

$$\times D(v,T)\, d\,v\, d\,\tau \;\Big\}. \tag{7}$$

Not yet known average value α_2 was calculated by the following classical relation [7-9]

$$\alpha_2 = \frac{1}{L\Theta}\int_0^{\Theta}\int_0^{L}\left[C_2(x,t) - C_1(x,t)\right] d\,x\,d\,t\,. \tag{8}$$

Using the above relation gives a possibility to obtain the following relations for the considered average value in the following final form

$$\alpha_2 = \left[\frac{1}{2}\int_0^{\Theta}(\Theta - t)\int_0^{L}(L + x)^2\, C_1(x,t)\frac{\partial D(x,T)}{\partial x}\, d\,x\,d\,t - \int_0^{\Theta}(\Theta - t)\int_0^{L}(x - v)\, D(x,T)\, C_1(x,t)\, d\,x\,d\,t + \right.$$
$$+ 2\int_0^{\Theta}(\Theta - t)\int_0^{L}x^2\, C_1(x,t)\frac{\partial D(x,T)}{\partial x}\, d\,x\,d\,t + \frac{S}{2V\,h}\int_0^{\Theta}(\Theta - t)\int_0^{L}(L + x)^2\, D(x,T)C_1(x,t)N(x,t)d\,x\,d\,t +$$
$$+ \frac{2S}{Vh}\int_0^{\Theta}(\Theta - t)\int_0^{L}x^2 D(x,T)\, C_1(x,t)\, N(x,t)d\,x\,d\,t - \frac{1}{2}\int_0^{\Theta}(\Theta - t)\int_0^{L}\left(L^2 - x^2\right)C_1(x,t)\frac{\partial D(x,T)}{\partial x}\, d\,x\,d\,t -$$
$$- \int_0^{\Theta}\int_0^{L}x(L - x)\, f(x)d\,x\,d\,t - L\int_0^{\Theta}\int_0^{L}(L - x)C_1(x,t)d\,x\,d\,t + L\int_0^{\Theta}(\Theta - t)\int_0^{L}(L - x)D(x,T)\, C_1(x,t)\, d\,x\;d\,t +$$
$$\left. + \frac{1}{2}\int_0^{\Theta}(\Theta - t)\int_0^{L}\left(L^2 + x^2\right) D(x,T)C_1(x,t)d\,x\,d\,t + 2\int_0^{\Theta}(\Theta - t)\int_0^{L}x^2\, C_1(x,t)\, D(x,T)\, d\,x\,d\;t\right] \times$$
$$\times \left[\int_0^{\Theta}(\Theta - t)\int_0^{L}(x - v)D(x,T)\, d\,x\,d\,t - \frac{1}{2}\int_0^{\Theta}(\Theta - t)\int_0^{L}(L + x)^2\,\frac{\partial D(x,T)}{\partial x}d\,x\,d\,t + 2\int_0^{\Theta}\int_0^{L}x^2\,\frac{\partial D(x,T)}{\partial x}d\,x \times\right.$$
$$\times (\Theta - t)\, d\,t - \frac{S}{2V\,h}\int_0^{\Theta}(\Theta - t)\int_0^{L}(L + x)^2\, D(x,T)N(x,t)\, d\,x\,d\,t - \int_0^{\Theta}(\Theta - t)\int_0^{L}x^2\, D(x,T)N(x,t)\, d\,x\,d\,t \times$$
$$\left. \times \frac{2S}{Vh} + \Theta^2\,\frac{L^3}{4}\right]^{-1}. \tag{9}$$

The distribution of the considered concentration of medicinal product in space and time was analyzed analytically by using the second-order approximation, which was obtained by using of the method of averaging of function corrections. The approximation is usually enough good approximation for to make qualitative analysis and to obtain some quantitative results. All obtained results have been checked by comparison with results of numerical simulations.

3. DISCUSSION

In this section we present an analysis of spatio-temporal distribution of concentration of medicinal product in organism. Figs. 1 and 2 shows typical dependences of the considered concentration on time and coordinate, respectively. The obtained dependences qualitatively coincides with analogous experimental distributions. Increasing of temperature of organism leads to acceleration of interaction of the considered medicinal product with other substances of the organism in the considered interval of temperature.

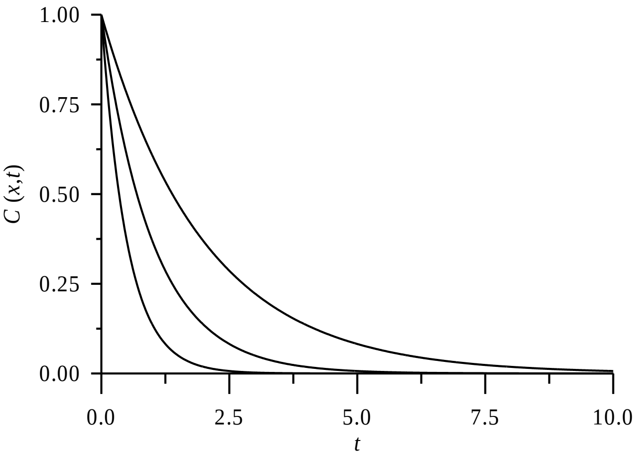

Figure 1. Dependences of concentration of considered medical product on time in the typical form

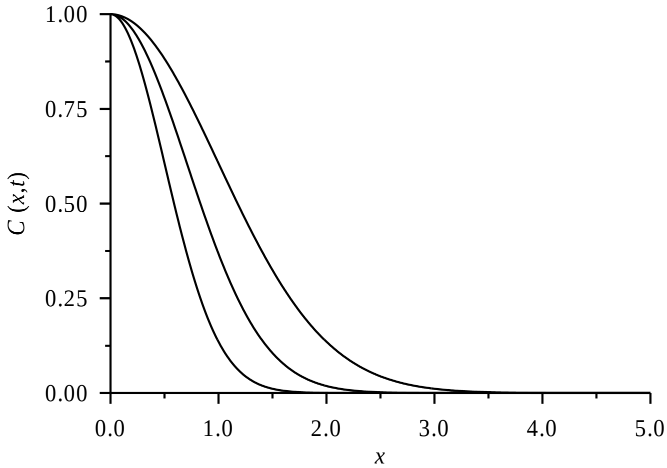

Figure 2. Dependences of concentration of considered medical product on coordinate in the typical form

4. CONCLUSIONS

In this paper we consider analysis of dissolution of a medicinal product in an organisms. The analysis based on estimation of spatio-temporal distribution of concentration of the above product during the dissolution. We introduce an analytical approach for analysis of the above dissolution with account changing of it's conditions. We consider possibility to accelerate and decelerate of dissolution of medicinal products in organisms.

REFERENCES

[1] Petrov, V.I., Ryazanova, A.Yu., Prival'tseva, N.S. & Nekrasov D.A. (2022). "Polypharmacy in the treatment of inpatients with a new coronavirus infection COVID-19". Pharmacy and pharmacology. Vol. 10, No. 3, pp 267-277.

[2] Severskaya, E.N., Eltyshova, T.E., Karpov, D.S., Korobkina, M.P. Zaikina, P.G. (2022). " Application of biosimilar insulin analogues aspart and lispro in the pump" Russian medical journal. No 1, pp. 9-14.

[3] Shavlovskaya, O.A. (2022). "Possibilities of using chondroitin sulfate in patients with chronic back pain." Russian medical journal. No. 7, pp. 32-38.

[4] Kakhramanova, S.D., Bokov, D.O. & Samylina, I.A. (2020). " Quantification of polysaccharides in medicinal plant raw material." Pharmacy. Vol. 69, No. 8, pp. 5-12.

[5] Progozhina, Yu.E. Dzhavakhayan, M.A. & Bobkova, N.V. (2022). " Vitamins, iron, zinc, selenium, selenium-containing drugs in the complex prevention of complications and treatment of patients with COVID-19." Pharmacy. Vol. 71, No. 1, pp. 18-24.

[6] Fedulenkova, Yu.Ya. (2023). "Role of echography and computed tomography in diagnosis of chronic diffuse liver diseases". Pharmaceutical and Biomedical Sciences: An International Journal. Vol. 1, No. 1, pp. 9-14.

[7] Sokolov, Yu.D. (1955). "About the definition of dynamic forces in the mine lifting". Applied mechanics. Vol. 1, No. 1, pp. 23-35.

[8] Pankratov, E.L. & Bulaeva, E.A. (2014). "An approach to decrease dimensions of field-effect transistors without p-n-junctions." International Journal of Modern Physics B. Vol. 28, No. 27, pp. 1450190-1--1450190-17.

[9] Pankratov, E.L. & Bulaeva, E.A. (2015). "On optimization of regimes of epitaxy from gas phase. some analytical approaches to model physical processes in reactors for epitaxy from gas phase during growth films." Reviews in Theoretical Science. Vol. 3, No. 4, pp. 365-398.