16. EDUCATIONAL APPLICATION OF ACID–BASE, VOLUME AND ELECTROLYTE MODELLING

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Introduction: Acid–base physiology is not only an important area of medical education, but also a difficult one to get agraspof. Idealgoal inteaching isto makethe student understand intuitively not only the changes of the commonly used acid–base variables, but also the internal state of acid–base balance. Furthermore, the connection between acid–base, volume and electrolyte physiology (emphasized especially by so called modern approach) needs to be depicted.Educational simulators seem to bean ideal teaching tool of acid–base and other complex concepts. Simulation games help the student understand the dynamics of physiological regulation and pathophysiological disorders of it.Our team creates web accessible educational multimedia simulators that can be used for demonstration in seminars, accessed from home and easily distributed worldwide (see http://www.physiome.cz/atlas). The simulator of the acid–base chemistry includes buffering systems, regulatory influence of respiration and kidneys and influence of ionic and volume homeostasis on acid–base status.

Methods: The model is based on our border flux balanceview of acid–base chemistry [1]. In this approach, blood Buffer system is described using following state variables[2]:

cCO2Tot—total concentration of CO2 in all its forms;BEox—base excess in fully oxygenated blood, haemoglobinconcentration, temperature and cO2Tot—total concentration o fO2 in all its forms that affects the buffering properties of haemoglobin;concentration of plasma albumin, globulin and phosphates. Neither buffering reactions nor the transfer of ions between various compartments (border fluxes) of bodily fluids do change electroneutrality. Fluxes of hydrogen ions or bicarbonates are always accompanied by the fluxes of complementary ions.

When creating educational simulators, we follow a standardized workflow. Underlying simulation model is created in simulation language Modelica. Modelica is a causal and declarative—i.e. the individual parts of the model are described directly as a system of equations and not as an algorithm to solve the equations. We have also used the Matlab Simulink environment. Educational webbased simulators created based on the underlying model in a standard development environment (eitherVisualStudio.NET, Adobe Flex builder). The model core is translation into these environments is mostly automatized. Wehave a powerful graphic team who are able to design both elegant and interactive multimedia interface. The interface is connected with the simulation model core in AdobeFlash or Microsoft Blend [3].

Results: The acid–base simulators are divided into twonblevels of complexity, where first level confers the basis understanding of the acid–base equilibriums, while the second level depicts the basic ideas of the fluxes of the ions and gases between different body compartments, as well as the basics of the regulation of these fluxes. First level is a simulation model of the acid–base chemistry in plasma.

The model is implemented in Adobe Flash. It shows how the two buffering systems of plasma (bicarbonate and non-bicarbonate, i.e. albumin and phosphate) are connected.

Using this model, students can learn why actual bicarbonate varies with pCO2 while BE stays constant and why BE decreases with buffering. Using the modern theory parameters, students can see why changing Atot with SIDE kept constant results in effective removal of acid and alkalosis. Finally the model describes the changes of the buffer systems that occur with dilution acidosis and contraction alkalosis.

Second level of complexity includes the whole blood, as well as interstitial fluid and ions. We have this model implemented in Modelica environment and are currently working on the multimedia simulator based on it. The model can be used for demonstrating conditions like hyperchloremic acidosis, changes of SID in full blood due to chloride shift resulting from changes of pCO2 and fluxes of hydrogen ions from cells to the system.

The plasma model wasted in education,with models either being or not being used in seminars on acid base. There was a significant difference between the two groups (Figure 1).

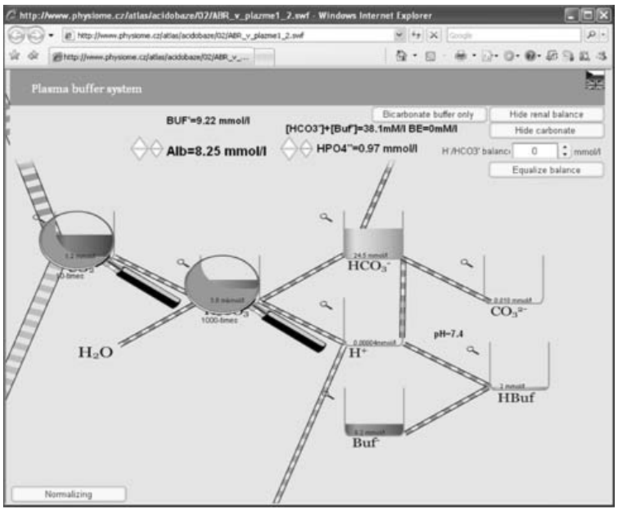

Fig. 1. Simulation model of pl.

Discussion: Currently, a debate still exists as to whether the so called traditional or modern approaches to the acidbase provide better understanding of a patient. Our educational simulators can provide understanding of both these approaches and their interconnectivity, brought about by buffering system equilibriums. However, the most practical look at acid base might be the proposed border flux approach. This is because physiological regulation is carried out on the level of fluxes of the quantities represented by state variables (different from Stewart's independent variables) in and out of the system.

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