Response of Ion-Selective Sodium and Potassium Electrodes in the Beckman Astra 4 and Astra 8 Analyzers

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We tested the response of ion-selective sodium and potassium electrodes that are a part of the new multi-channel chemical analyzers, Astra 8 and Astra 4 (Beckman). For this we used plain and albumin-containing aqueous solutions of known Na+ and K+ concentrations, varied inversely so we could assess how the concentration of each electrolyte would affect the response of the other electrode. The stability of the electrodes with time was good and the electrodes are indeed selective for Na+ and K+.

In the last few years, analytical systems involving the use of electrodes other than the glass electrodes or polarographic electrodes used for determining pH, pO2, pCO2 have been developed (1).

Ion-selective electrodes facilitate assessing the ionic state of the serum, are simpler to use than flame photometry, require less sample, and provide data quickly.

Materials and Methods

The “Astra 4” and “Astra 8” analyzers (Beckman Instruments, Chemin des Bourdons, 93220 Gagny, France) are equipped with a module that incorporates Na-selective (glass membrane) (2), K-selective (valinomycin-impregnated plastic membrane) (3) and reference electrodes. With a simple program modification, both instruments can simultaneously determine Na+ and K+ in either plasma or urine with the same calibration parameters.

We studied the electrode response, using aqueous solutions of known Na+ and K+ concentrations ranging from 2.5 to 200 mmol/L.

Na+ and K+ concentrations were inversely varied, to see how the concentration of one of the electrolytes influenced the response of the other electrode. Use of aqueous solutions also made it possible to study the urine program.

We also tested electrode response with use of an albumin solution with Na+ and K+ concentrations varied from 2.5 to 200 mmol/L; interference by I− was also evaluated.

We studied electrode responses to two aqueous calibrators, I and II (Calibrator I: Na+ 140 mmol/L and K+ 4 mmol/L; Calibrator II: Na+ 180 mmol/L and K+ 8 mmol/L), using Analogic Digital Converted Values (ADC), during 45 days. Each of the measurement channels has a separate signal conditioner, and the various analog signals are converted into digital values for entry into the central processing unit. The ADC provides accurate and precise conversions.

Results

Figures 1 and 2 show that the electrode responses were the same whether the solutions used were aqueous or proteinaceous.

We also found that:

(a) The Na+ electrode response is very stable, as judged from changes in the ADC values with time during 45 days. Such differences are relatively constant (mean difference between Calibrators I and II was 215 ADC, extreme values 200, 225 ADC).

(b) The K+ electrode response varies with time, but the difference in the ADC values between the Calibrators I and II is always constant (mean difference between Calibrators I and II was 260 ADC, extreme values 224, 267 ADC).

(c) The program for plotting the standard curve is fairly complex: the Na+ and K+ electrode responses do not quite follow a logarithmic equation but rather a third-degree polynomial equation for the Na+ electrode, a fourth-degree for the K+ electrode. The deviation of the response curve observed relative to the linearized response on semi-logarithmic paper, for example, varies from 12% for the extreme values to 0.2% for those values near those for the standard solutions.

(d) These electrodes are extremely selective for the measured ions; we saw no reciprocal interferences. For example,
valinomycin’s selectivity for potassium is nearly 5000:1 over sodium (4). For I⁻ interference we studied iodine concentrations up to 40–50 mmol/l. Variations in the K⁺ electrode response ranged from 5 to 10% and this variation increased with the age of the electrodes (5, 6).

Discussion
The response curve gives a good indication of the electrode life. In fact the constancy of the ADC values for the Na⁺ electrode indicates its long life. In contrast, the K⁺ electrode changes relatively quickly (two months, according to our experience) as is evidenced by the ADC values for this electrode, which indicate replacement of the K⁺ electrode when the ADC difference between Calibrator I and II is less than 200. One may also stress the constancy of the difference in the ADC values between Calibrators I and II for these two electrodes. The polynomial response of these electrodes suggests a simplified model of response formed by a two-division system (6). Iodine especially interferes with K⁺ determination, because I⁻ forms a complex with potassium and thus modifies the

relation between the physical structure of the valinomycin membrane and potassium, preventing the latter from fixing onto this membrane, because the ion-exchange cavities that the valinomycin membrane forms nearly equal the diameter of the potassium ion.

References

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Parallel Evaluation of Astra 8 and Astra 4 Multichannel Analyzers in Two Hospital Laboratories

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We evaluated the new Beckman multichannel analyzers Astra 8 and Astra 4. Both instruments performed the following tests: Na, K, Cl, CO₂, urea, glucose, and creatinine in plasma and Na, K, Cl, and creatinine determinations in urine. We tested precision, accuracy, and linearity at the usual concentrations in plasma and urine. We compared the Astra 8 and Astra 4 with continuous-flow (SMA 6) and discrete analyzers such as IL 243, Beckman KLiNa Flame, Beckman System 1, Corning 920 M Chloride Meter, and the Corning Blood-Gas Analyzer 175. Special tests were performed on plasma-to-plasma and urine-to-plasma carryover. Both analyzers are easy to operate and suitable for both emergency and routine use.

In a previous evaluation (1), we find a description of the "Astra 8" (Beckman Instruments, Inc., Fullerton CA 92634) and a study of its precision, linearity, and correlation with results with a SMA 6/60 and DuPont accr for serum samples.

Recently, new programs allowing direct determination of Na⁺, K⁺, Cl⁻, and creatinine in urine have been developed for the Astra. The instrument can test plasma and urine samples in the same run as required, through modification of either the value-calculation program (Na⁺, K⁺, Cl⁻, creatine), the sample-pickup volume (Cl⁻, creatinine), or the timing of the reaction (Na⁺, K⁺, Cl⁻).

We tested precision and linearity at the usual concentrations in plasma and urine, and plasma-to-plasma and urine-to-plasma carryover. We expanded the correlation study to other instruments. A special study of Na/K-selective electrodes is the subject of the preceding Note.

Materials and Methods
The evaluation was performed at two different laboratories.²

The Astra 8 and all necessary reagents were provided by the company (Beckman Instruments France, Gagny, France), and the following tests were available for the study: Na⁺, K⁺, Cl⁻, CO₂, urea, glucose and creatinine.

The Astra 8 was installed at the Meaux laboratory.¹ Instruments used in the comparison study were:

—The SMA 6⁺ (Sequential Multiple Analyzer, Technicon Instruments, Domont, France) in the following configuration: glucose, urea, Na, K, Cl, CO₂, proteins, and creatinine. Test procedures used: Na and K (flame emission, propane), CO₂ (cresol red), Cl (mercuric thiocyanate), creatinine (Jaffé), glucose (Boehringer procedure with use of glucose oxidase), and urea (diacetylmonoxime).

—The IL 243 flame photometer (Instrumentation Laboratory, Delhorne, France) for Na⁺ and K⁺ determinations (flame emission, propane).

—The Beckman System 1 (Beckman Instruments) for urea (conductivity rate method using urease) and glucose (oxygen rate method involving PO₂ and glucose oxidase) determinations.

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