Benzalkonium Interference with Test Methods for Potassium and Sodium

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Six automated instruments that measure sodium and potassium were tested for interference from two compounds used in catheters. Tridodecylmethylammonium heparin did not interfere with any of the methods. However, benzalkonium heparin falsely increased sodium measurement with the Kodak Ektachem, and falsely increased potassium measurements with three instruments (Beckman Astra, Baxter Paramax, and the Instrumentation Laboratory Monarch) in which ion-selective electrodes measure potassium in diluted serum. Three instruments in which ion-selective electrodes measure serum directly—Du Pont Dimension, Abbott Spectrum, and Kodak Ektachem—experienced no interference with potassium measurements. Interference of benzalkonium with potassium measurements may result from its interaction with the electrode membranes, which is accentuated in diluted serum.

Abnormalities of potassium and sodium are among the serious life-threatening disorders encountered frequently in acutely ill patients that are correctable by appropriate fluid therapy. Consequently, erroneous measurements of serum potassium or sodium have the potential to cause therapeutic errors that could result in serious injury or death to patients.

Previous reports (1, 2) have described the interference of benzalkonium (used in combination with heparin as a coating material for catheters) with the Kodak Ektachem test for sodium and with the Beckman Astra test for potassium. Here, we report results of experiments designed to study possible effects of benzalkonium with other methods for sodium and potassium. Also, we investigated for possible interference an alternative compound in catheters used by one manufacturer.

Materials and Methods


Analytical systems: Astra-8 (Beckman Instruments, Inc., Brea, CA 92621); Ektachem 700 (Eastman Kodak Co., Rochester, NY 14650); Paramax (Baxter Healthcare Corp., Irvine, CA 92718); Parallel (American Monitor Co., Indianapolis, IN 46268), flame-photometric reference test
method; Spectrum (Abbott Laboratories, North Chicago, IL 60064); Monarch (Instrumentation Laboratory, Lexington, MA 02173); Dimension (E. I. du Pont de Nemours & Co., Wilmington, DE 19898).

**Procedures:** We designed an experiment to simulate the introduction of coating materials into blood collected through catheters. We prepared a pool of a commercial control serum (Serachem; Fisher Scientific, Pittsburgh, PA 15219) and drew the serum, in 5-mL segments, through a new catheter of each type. In all, we drew 10 segments through each catheter, and collected the segments sequentially in numbered tubes. Aliquots from the same pool were interspersed among the samples to serve as controls for drift of the analytical systems.

Sets of this series of 26 samples were sent for analysis to laboratories using the instrument systems indicated. Before analysis with each system, the individual laboratories confirmed that the sodium and potassium tests were performed within the quality-control specifications of that laboratory. Then the samples were analyzed in series without interruption of the sequence.

**Results**

When serum was passed through the Tri-Lumen catheter, containing tridodecylmethylammonium heparin, none of the analytical systems showed interference in the tests for sodium or potassium.

Results for potassium analysis in samples passed through the benzalkonium heparin-coated catheter are depicted graphically in Figure 1. The Dimension, Spectrum, and Parallel systems showed no significant effect of benzalkonium heparin on sodium or potassium measurement. However, potassium measured with the Astra, Paramax, and Monarch systems was falsely increased. For all systems the effect was greatest in the first and second 5-mL segments of serum. After the third segment, no system showed interference.

The Ektachem measurement of sodium encountered interference from benzalkonium in the first three 5-mL segments, after which results were unaffected by passage through the catheter.

**Discussion**

The results of this investigation confirm and extend our previous report of interference of benzalkonium with the Astra potassium and the Ektachem sodium test methods (1). Our approach to testing for interference was intended to simulate the introduction of catheter materials into blood collected through in-dwelling catheters. In our institution, it is common practice for medical personnel to "clear" the catheter line by withdrawing and discarding 5 mL of blood before collecting the test sample. However, as our results demonstrate, when collecting a specimen for sodium or potassium analysis through a newly inserted catheter, this procedure is insufficient to remove the interfering coating material.

All of the methods that exhibit interference with potassium measurements (Astra, Monarch, and Paramax) are based on indirect measurement with ion-selective electrodes; i.e., samples are diluted before presentation to the electrode. The Dimension, Ektachem, and Spectrum systems, which showed no interference, measure serum directly with their ion-selective electrodes.

Ion-selective electrodes exhibit selection toward different ionic species, in that a given electrode is more responsive to the same concentration of one ion than of another. However, for all monovalent cations, the response follows the same nernstian equation; thus, an electrode should exhibit the same change in response to the same change in concentration of the two ions. The relationship of potassium to benzalkonium concentrations is the same in undiluted sample and in the same sample after dilution. However, the relative response is dramatically different in diluted and undiluted samples, which suggests that some phenomenon other than simple electrode selectivity is involved in the interference of benzalkonium with potassium measurements. Perhaps adsorption or some other type of interaction with the electrode membrane temporarily alters the membrane's surface properties. Because benzalkonium is a surfactant, this sort of interaction would not be completely surprising.

The errors caused by benzalkonium with the Ektachem sodium test and with the Astra potassium test have been previously reported (1, 2). The additional information that two other common instrument systems experience interference by benzalkonium with potassium measurements strongly suggests that this source of errors is widespread. We speculate that all systems in which valinomycin-based ion-selective electrodes are used for measuring potassium in diluted samples may be subject to this interference. In contrast, because the Ektachem sodium method involves a unique ionophore, it is unlikely that other systems would exhibit this same interference with sodium tests.

Because potassium abnormalities may be life-threatening, we regard the existence of an interfering substance in catheters used in populations most at risk for potassium abnormalities (i.e., the intensive-care population) as a serious threat to the well-being of patients in U.S. hospitals. The existence of an alternative that does not cause this interference presents the option of prompt corrective action by manufacturers. At the least, manufacturers of test systems affected adversely by benzalkonium should warn laboratories of this potentially dangerous problem.

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**References**