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A Comparison of Methods of Blood Withdrawal and Sample Preparation for Potassium Measurements

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The effect on measured potassium values of a number of factors involved in sample acquisition and preparation were investigated. Measured potassium values in either plasma or serum were not influenced by the site of sample withdrawal, the presence of a tourniquet, or the time elapsed between blood sampling and analysis. However, increasing heparin concentrations and/or volumes decreased potassium values. The highest values were obtained in samples obtained in a syringe that had been washed with minimum volumes of heparin. It is concluded that this common clinical practice is based on a sound scientific rationale. (Key words: Blood: anticoagulants, heparin. Ions: potassium. Measurement techniques: electrodes, potassium.)

Rapid and frequent measurement of potassium levels has become commonplace during anesthesia and surgical procedures with the advent of the ion-selective analyzer. The convenience of this instrument is enhanced by the availability of indwelling cannulas as a means for blood-sample withdrawal. It has been reported that potassium levels in plasma are 0.1–0.7 mEq/lower than those found in serum, presumably due to release of potassium from ruptured platelets during the coagulation process.† Ward et al.‡ found a difference between arterial plasma and venous serum samples that ranged from 0.1 to 1.3 mEq/l and stated that immediate potassium therapy in an asymptomatic patient whose arterial plasma potassium is greater than 2.7 mEq/l is not justified. Hill et al.** found no significant difference in central venous and arterial potassium levels regardless of whether the samples were heparinized plasma or unheparinized serum. In view of these discrepancies, we designed the following study to investigate the effects on potassium values of 1) the presence of heparin, 2) various heparin concentrations, 3) sample dilution, 4) site of withdrawal, 5) effect of tourniquet, and 6) the time elapsed between blood sampling and analysis. We hoped these data would define the optimal conditions for obtaining blood samples for potassium measurements from indwelling cannulas.

Materials and Methods

The study met the criteria of our institutional review board for informed consent. Forty patients were studied during surgical procedures requiring cardiopulmonary bypass. Prior to induction of anesthesia, a 20-gauge cannula was inserted in a radial artery and a Swan-Ganz catheter was placed in a pulmonary artery via the right internal jugular vein. Two 16-gauge peripheral venous cannulas were placed. The study was done in two parts.

Group I (20 patients). From each patient, after careful aspiration of twice the dead space, blood was simultaneously withdrawn from the arterial cannula, the central venous port of the Swan-Ganz catheter, and the venous catheter, which had been infused with NaCl, 0.9 per cent, at a minimal rate to prevent clotting. The infusion was stopped prior to application of a tourniquet and the venous sample drawn 5 min later. Two samples were withdrawn from each site into a 3-ml plastic syringe. One sample was withdrawn into a syringe prepared with 10 μl of heparin (10 IU) using a micropipette and withdrawing blood to a total volume of 2 ml. These samples were analyzed for potassium levels within 5 min of sampling and again 40 min after sampling. A second unheparinized sample was also obtained from each site. This was allowed to stand for 20 min at room temperature, centrifuged 1,000 × 1 g for 20 min, and subsequently analyzed for potassium levels.

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Fig. 1. Effect of time elapsed between sample withdrawal and analysis on plasma potassium values.

Group II (20 patients). In these patients, six samples were obtained from the arterial line only. The samples contained various volumes and concentrations of heparin (as in fig. 4). One of the samples (referred to as "wash") was obtained in a syringe prepared by aspirating a small volume of heparin, coating barrel and plunger, and subsequently expelling as much solution as possible. The amount of heparin remaining was estimated to be approximately 10 μl (10 IU). All samples from each patient were drawn in random order following aspiration of twice the dead space of arterial blood in the indwelling cannula. Each syringe was filled to a total volume of 2 ml. The samples were analyzed 5 min after collection.

All samples were analyzed in random order on an Orion® SS30 Sodium/Potassium analyzer with an ion-exchange electrode. Daily aqueous calibration standards and serum controls were measured. In replicate samples, this instrument achieved a standard deviation of no greater than 1.5 per cent of measured values.

Statistical analysis of the data was accomplished using the Students t test for paired data. Since the direction of expected changes could not be predicted prior to the study, a two-tailed test was performed.

Results

Potassium values in Group I ranged from 3.15 to 6.70 mEq/l. Mean plasma potassium values did not differ significantly with time of analysis (fig. 1). There was no significant difference in plasma or serum potassium values regardless of site of withdrawal or use of a tourniquet (fig. 2). There was a highly significant difference when samples drawn from the same site were paired on the basis of the presence or absence of heparin (fig. 3). Of the 60 observed differences,
59 fell between 0.01 mEq/l and 0.41 mEq/l, with only one observed larger difference (0.79 mEq/l). The mean differences ± SEM between heparinized (plasma) and unheparinized (serum) samples were: peripheral venous blood, 0.121 ± 0.027; mEq/l; arterial blood, 0.113 ± 0.025 mEq/l; central venous blood, 0.103 ± 0.023 mEq/l.

In contrast, potassium values in Group II ranged from 2.26 to 4.98 mEq/l. The differences in observed values ranged from 0.02 to 1.55 mEq/l. There was no significant difference in potassium values when samples prepared with 10 IU (10 μl) of heparin were compared with samples collected in a syringe washed with heparin (fig. 4). There was a significant difference between samples prepared with 200 μl and with 400 μl of heparinized solution, depending on the number of units of heparin present. Therefore, a definite effect of heparin concentration was noted. There was also a significant difference when samples containing 10 IU of heparin were paired on the basis of volume of diluent.

**Discussion**

It has been shown that opening and closing the fist during venipuncture with a tourniquet in place results in an increase in serum potassium of 10 to 20 per cent, and that this condition persists for approximately 2 min. This factor may account for the large differences between venous serum and arterial plasma potassium.
values observed by Ward et al. It is clear from our results that the use of a tourniquet with resultant stasis does not affect potassium levels in the absence of arm movements. The results from Group I show that the addition of small amounts of heparin to a sample will result in a statistically significant decrease in observed potassium values, but that this decrease is not usually clinically significant. That this difference is due mainly to the action of heparin rather than any inherent differences between plasma and serum is apparent from the results of Group II in which observed potassium values decreased significantly with either increasing heparin volumes or increasing heparin concentrations.

These data demonstrate that site of sampling, time of analysis, and use of a tourniquet in the absence of arm movements have no effect on measured potassium values, but that the volume and concentration of heparin used to prepare samples for analysis do have marked effects. We conclude that when heparin is limited by the use of a micropipette, or, in the clinical setting, by the more convenient alternative of washing the syringe with heparin 1,000 IU/ml, indwelling cannulas provide a convenient route for sampling, and that the criteria for treatment of abnormal potassium levels are the same regardless of site of withdrawal or whether the sample is plasma or serum.

References
