ratio 1.93. The patient's condition had worsened at readmission on May 30, 1994. His general condition was very poor, with weight loss and dehydration. Clinical examination showed lymph nodes in laterocervical and supravaculectic sites but no hepatosplenomegaly. Electrophoretic and immunofixation studies showed a narrow peak (12.5 g/L assessed by densitometry) in the beta region (gamma heavy chains) and a clear decrease of protein in the gamma region. Immunoglobulin concentrations decreased as follows: total protein 51 g/L, IgG 32.1 g/L, IgA 2.8 g/L, IgM 1.53 g/L, light \( \kappa \) chains 1.92 g/L, light \( \lambda \) chains 0.87 g/L, and \( \kappa/\lambda \) ratio 2.21. The sudden death of the patient 40 h after this admission precluded studies of Bence Jones protein; however, routine urinalysis showed 0.3 g/L protein.

The dramatic worsening of the general condition and the death of the patient suggest that the sudden appearance of heavy chains in a patient with Hodgkin disease could herald an unfavorable progress.

References

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Interlaboratory Testing Scheme Designed as a Clinical Chemistry Control Procedure

To the Editor:

Despite all efforts, quality control (QC) of the eight clinical chemistry laboratories in our region was unsatisfactory. The main source of problems was the four peripheral laboratories, 150–300 km from our control laboratory. It is known that QC in such laboratories may present more difficulties than in centralized laboratories (1).

To try to solve the problem, we introduced a chemistry interlaboratory testing scheme. We designed it specifically to have a short turn-around time so that we could monitor the laboratories closely and intervene soon after errors were made.

The protocol for the trial was straightforward. An aliquot of a fresh pool of liquid serum was sent every week to each laboratory, which was required to test for a prescribed list of 19 routine chemistry analytes and fax the results to the control laboratory within a day. The effective turn-around time was always <3 days. Obviously, because of the small sample size (n = 8), there is no good statistical way to determine probable error. We therefore assessed the results by calculating the standard deviation index (SDI = (result - mean) / SD), and by comparing the results against a "target" value for the analyte (i.e., the best result our reference laboratory could obtain for each analyte in that sample). Assays having an absolute SDI ≥2.00 were suspect. We set arbitrary limits above and below the target values (e.g., ±7% for urea), and results that exceeded these were suspect. Although these tests for errors are clearly not perfect, in practice, and considered together, they proved surprisingly sensitive. Suspect results were regarded as errors and a senior staff person would phone to investigate the cause and counsel the technologists. The entire proficiency test was completed within 3 days.

The scheme was carried out in parallel with the conventional QC procedures that were in place.

We ran the trial for 60 weeks. Soon after starting it, severe interlaboratory imprecision was highlighted, probably because the laboratories were using different reagents from different manufacturers. We therefore standardized the testing materials (test kits, calibration, control, and precision reagents). After numerous trials, we selected only those products that performed well in our hands. This exercise took place during the initial 20 weeks of the trial.

Figure 1 presents the 4-week moving averages of the sum of the CV for all 19 analytes each week. Their downward trend indicates reduction in interlaboratory imprecision. By the 60th week the values had dropped from ~150% to 70%, a decline of 50%.

We also compared the average of all the CV values for each 20-week period. The 2nd-period average was 40% less than the 1st (we attribute this improvement mainly to stan-
We recently demonstrated that ionized calcium at actual pH should be preferred in cases with rapid acid–base changes (2). Such changes also occur during delivery. Others have presented data for actual ionized calcium at actual pH in umbilical cord blood (2–5), but these studies are based on small numbers of subjects. In a prospective study of normal pregnant women, we measured actual ionized calcium, both at actual pH and adjusted to pH 7.40 in 74 samples obtained immediately after delivery from umbilical cord arteries and veins.

From January 1 to May 31, 1994, all pregnant women who were admitted to deliver at Hvidovre Hospital, University of Copenhagen, were invited to participate in the present study. A total of 74 women accepted participation and were subsequently included as they fulfilled the following criteria: single gestation, uncomplicated pregnancy, spontaneous childbirth at 37–42 weeks, cephalic presentation, Apgar scores >8 at 5 min after birth, uncomplicated neonatal period, and birth weight appropriate for gestational age. All patients gave informed consent to participate. The study was approved by the local ethical committee.

Blood samples were collected anaerobically from the umbilical cord artery and vein immediately after the umbilical cord was clamped. Syringes containing calcium heparin (QS 90; Darmeyer, Copenhagen, Denmark) were used for blood collection, and actual and adjusted ionized calcium (pH 7.40) and pH were measured simultaneously at 37°C with an ABL 505 analyzer (Radiometer) just after the sample was collected.

We observed identical values in arterial and venous umbilical cord blood for actual ionized calcium at actual pH; however, the adjusted ionized calcium (pH 7.40) and the pH were significantly lower in arterial cord blood than in venous cord blood (Table 1). There was a significant relationship between actual and adjusted ionized calcium in umbilical cord arteries and veins (r = 0.71, P < 0.001, and r = 0.66, P < 0.001, respectively), but no statistically significant relationship was found between pH and actual ionized calcium.

In our study the values for actual ionized calcium at actual pH in arterial and venous umbilical cord blood are lower than the values observed by Wandrup et al. (t = 4.17, P < 0.001, and t = 2.99, P < 0.01, respectively).

The pH, on the other hand, did not differ significantly between the two studies. Thus, it is unlikely that the observed differences in pH explain our finding of lower actual ionized calcium. Furthermore, in contrast to another study (7), the relationship between actual ionized calcium and pH was significant in neither arterial nor venous umbilical cord blood.

In normal subjects actual ionized calcium changes with changes in pH, mainly because the binding capacity and affinity of albumin change with pH. The explanation for the lack of correlation is not clear but may be due to the rapid acid–base changes during delivery, or influence by phosphate or other anions. Because the concentration of albumin in umbilical cord blood is close to that in maternal blood (7), it is unlikely that changes in albumin account for the lack of relationship in our study.

The measured actual ionized calcium is used to calculate a standardized ionized calcium at pH 7.40, based on the pH dependency of ionized calcium. Because we found no such relationship in either arterial or venous umbilical cord blood, this calculation may be misleading. Our observation of a weak relationship between actual and adjusted ionized calcium supports this conclusion. Therefore, we recommend that only actual ionized calcium at actual pH should be used for measurement of calcium in umbilical cord blood.

### References

3. Reitz RE, Daane TA, Woods JR, Weinstein RL. Calcium, magnesium, phopho-

### Table 1. Mean (SD) actual and adjusted ionized calcium (pH 7.40) and pH in umbilical cord blood (n = 74).

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Adjusted</th>
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<tbody>
<tr>
<td>Arterial cord blood</td>
<td>1.40 (0.06)</td>
<td>1.28 (0.06)</td>
</tr>
<tr>
<td>Venous cord blood</td>
<td>1.39 (0.08)</td>
<td>1.34* (0.09)</td>
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*Significantly different from arterial value (P < 0.0001).

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**Lack of Relationship Between Actual Ionized Calcium and pH in Umbilical Cord Blood**

**To the Editor:**

Recently, reference intervals for 21 analytes in umbilical cord blood were presented, including total calcium (1). However, measurement of total calcium in umbilical cord blood may be less useful than measurement of ionized calcium.

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