The effect of prolonged tourniquet application on serum bicarbonate

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■ **BACKGROUND** Many clinicians believe that prolonged tourniquet application lowers the serum bicarbonate concentration in samples drawn from that limb, but this effect has never been examined prospectively.

■ **OBJECTIVE** To test the effect of prolonged tourniquet application before phlebotomy on serum bicarbonate concentration in healthy adults.

■ **METHODS** We drew blood samples from 27 healthy adult volunteers without a tourniquet and again 1, 3, and 5 minutes after applying a blood pressure cuff and inflating it to the mean arterial pressure.

■ **RESULTS** The mean bicarbonate concentration was 27.3 ± 2.26 mmol/L (standard deviation) at baseline, 27.7 ± 2.39 mmol/L at 1 minute, 27.7 ± 2.05 mmol/L at 3 minutes, and 27.7 ± 1.96 mmol/L at 5 minutes. The mean change in bicarbonate concentration from baseline was −0.04 ± 1.02 mmol/L at 1 minute, 0.44 ± 1.05 mmol/L at 3 minutes, and 0.44 ± 1.31 mmol/L at 5 minutes. The mean lactate concentration was 1.1 ± 0.28 mmol/L at baseline, 1.3 ± 0.65 mmol/L at 1 minute, 1.2 ± 0.52 mmol/L at 3 minutes, and 1.2 ± 0.36 mmol/L at 5 minutes. The mean change in lactate concentration from baseline was 0.15 ± 0.67 mmol/L at 1 minute, 0.11 ± 0.11 mmol/L at 3 minutes, and 0.12 ± 0.37 mmol/L at 5 minutes.

■ **CONCLUSIONS** Prolonged tourniquet application before phlebotomy does not lower the serum bicarbonate concentration in healthy adults.

■ INDEX TERMS: BLOODLETTING; BLOOD SPECIMEN COLLECTION; TOURNIQUETS; BICARBONATES ■ CLEVE CLIN J MED 1995; 62:68–70

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Adapted from a presentation to the Midwest Society for Pediatric Research, Chicago, Ill.

MANY CLINICIANS believe that leaving a tourniquet in place for a long time before phlebotomy lowers the serum bicarbonate concentration. Prolonged venous constriction can cause venous engorgement and slow blood circulation in the area distal to the tourniquet. These circulatory changes could lead to anaerobic metabolism, regional metabolic acidosis, increased blood lactate concentration, and, eventually, decreased serum bicarbonate concentration.

However, an extensive Medline search of articles published from 1966 through June 1993 found no studies that tested the effect of prolonged tourniquet application on serum bicarbonate concentration. We believed that this hypothesis needed to be investigated, because if it is correct, many people would falsely be found to have metabolic acidosis.

OBJECTIVE

To test the effect of prolonged tourniquet application before phlebotomy on serum bicarbonate concentration in healthy adults.

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MATERIALS AND METHODS

Twenty-seven healthy volunteers age 18 and older with no medical problems predisposing them to metabolic acidosis were studied in the outpatient department of The Cleveland Clinic Foundation from March 30 to April 5, 1993. The study was approved by the Institutional Review Board.

We measured the blood pressure, weight, and height of each subject and then used a butterfly needle to draw a baseline blood sample from an antecubital vein without using a tourniquet. We left this needle in place to draw the subsequent blood samples. We told the subjects to refrain from repeated fist clenching and unclenching during the procedure. We then pumped the sphygmomanometer up to the mean arterial pressure (diastolic pressure + [(systolic—diastolic pressure)/3]) and kept it there. (We chose the mean arterial pressure because it approximates the pressure normally applied with a tourniquet.) Blood samples were drawn at 1, 3, and 5 minutes after applying mean arterial pressure. To keep the butterfly needle and tube open and flushed, 0.5 mL to 1.0 mL of blood were drawn immediately before each sample and at 2 and 4 minutes. Samples were sent to the laboratory within 30 minutes on ice for assay of bicarbonate and lactate concentrations.

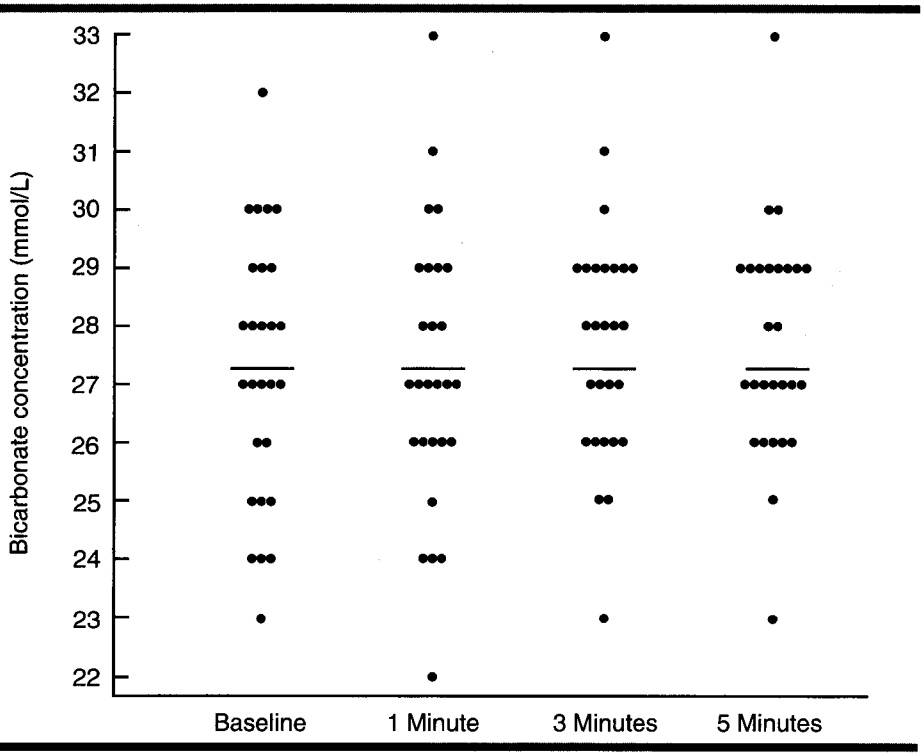

FIGURE. Serum bicarbonate concentrations before and 1, 3, and 5 minutes after tourniquet application. Bars indicate the mean values.

Lactate concentrations were determined before centrifugation with a YSI (Dublin, OH) whole-blood analyzer according to the manufacturer's protocol. Bicarbonate (CO_2) concentrations were determined in plasma with an Ektachem-500 analyzer (Eastman Kodak, Rochester, NY) according to the manufacturer's protocol.

Our laboratory's range for normal bicarbonate values spans 4 mmol/L from the lowest to the highest, ie, from 24 mmol/L to 28 mmol/L. Therefore, in calculating sample size we chose a mean bicarbonate change of 6 mmol/L as significant because such a change would place even the lowest or highest normal value at least 2 mmol/L outside the normal range. A power calculation showed that a minimum sample size of 26 subjects was needed to show a 6 mmol/L change in bicarbonate concentration from baseline with a standard deviation of 3 mmol/L and a statistical power of .90. Repeated-measures analysis of variance (ANOVA) was used to examine the mean bicarbonate and lactate concentrations of the group across time. The Pearson correlation coefficient was used to examine relationships between average change in bicarbonate and lactate concentrations with weight and height.

RESULTS

The subjects were 16 men and 11 women. Their mean age was 35, weight 73 kg, blood pressure 115/78 mm Hg, and mean arterial pressure 91 mm Hg.

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The mean bicarbonate concentration was 27.3 ± 2.26 (standard deviation) mmol/L at baseline, 27.7 ± 2.39 mmol/L at 1 minute, 27.7 ± 2.05 mmol/L at 3 minutes, and 27.7 ± 1.96 mmol/L at 5 minutes (*Figure*). The mean change in bicarbonate concentration from baseline was −0.04 ± 1.02 mmol/L at 1 minute, 0.44 ± 1.05 mmol/L at 3 minutes, and 0.44 ± 1.31 mmol/L at 5 minutes. Because of low variability, the repeated-measures ANOVA indicated a significant change over time, with measurements at 3 and 5 minutes being higher than those at 1 minute ($P = .02$). However, the mean change at each time was well below the difference of 6 mmol/L chosen as clinically relevant during sample-size calculation, and we therefore considered these changes in bicarbonate concentrations clinically insignificant.

The mean lactate concentration was 1.1 ± 0.28 mmol/L at baseline, 1.3 ± 0.65 mmol/L at 1 minute, 1.2 ± 0.52 mmol/L at 3 minutes, and 1.2 ± 0.36 mmol/L at 5 minutes. The mean change in lactate concentration from baseline was 0.15 ± 0.67 mmol/L at 1 minute, 0.11 ± 0.11 at 3 minutes, and 0.12 ± 0.37 at 5 minutes. The change from baseline did not differ significantly across time ($P = .18$).

The average change in bicarbonate concentration did not correlate significantly with either weight ($r = .38$) or height ($r = .22$). Additionally, the average change in lactate concentration did not significantly correlate with either weight ($r = .20$) or height ($r = .19$).

No clinically significant changes were seen in either bicarbonate or lactate concentrations over time.

DISCUSSION

We found that applying mean arterial pressure for up to 5 minutes before phlebotomy did not decrease the serum bicarbonate concentration in adults. No significant correlation was found between the change in bicarbonate or lactate concentrations and height or weight.

The mean arterial pressure may not be equivalent to the pressure induced by a tourniquet. No published study addresses how much pressure a tourniquet exerts; we selected the mean arterial pressure because it constricts the vein for phlebotomy and is a standard value that makes our study easy to replicate.

One could apply pressure greater than mean arterial pressure, up to systolic blood pressure levels, and could apply pressure for a longer period. However, applying pressure at systolic levels decreases arterial blood supply, prevents venous return, and causes subsequent engorgement. Therefore, such pressures would not simulate clinical practice. Furthermore, we repeated the protocol at systolic pressure with two volunteers; from baseline to 5 minutes the bicarbonate concentration increased by 1 mmol/L in one subject and decreased by 1 mmol/L in the other, while lactate increased by 0.3 and 0.2 mmol/L, respectively. If pressure were applied for longer than 5 minutes, greater changes in serum bicarbonate and lactate concentrations might occur. But again, such a period would not simulate clinical practice. Tourniquets rarely, if ever, are applied for more than 5 minutes, so a longer period cannot account for the anecdotal reports. Hence, we concluded that prolonged tourniquet application before phlebotomy does not lower the serum bicarbonate concentration in healthy adults.

ACKNOWLEDGMENT

We would like to thank the pediatric staff, house staff, and nursing staff who volunteered and participated in the study, Cassandra Talerico for medical editing, and Shelley Gabor for typing the manuscript.

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