



Fact Sheet – Cowside Blood BHBA Testing with a Hand-Held “Ketometer”

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I. Background

Human patients with Type I diabetes mellitus are at risk for diabetic ketoacidosis and often need to monitor their blood β -hydroxybutyrate (BHBA). Monitoring blood BHBA is superior to monitoring urine acetoacetate using urine test strips. Abbott Laboratories has developed a very small hand-held meter (Precision Xtra™) that measures either whole blood BHBA or whole blood glucose. As far as we know, no other human glucometer can also function as a ketometer (i.e., able to measure blood BHBA). The Precision Xtra™ meter gives excellent results for measuring whole blood BHBA in cows. No additional calibration or adjustment from the human system is needed.

The Precision Xtra™ ketone monitoring system is a simple and direct electrochemical test (which may explain why it works well for both human and bovine blood). The ketone test strip contains the enzyme β -hydroxybutyrate dehydrogenase, which oxidizes BHBA to acetoacetate. This reduces NAD^+ to NADH. The NADH is then reoxidized to NAD^+ by an electron transfer mediator molecule. The electrical current generated by this conversion is measured by the meter and is directly proportional to the BHBA concentration.

For more info: <http://www.abbottdiabetescare.com/>; then select “Products”
then select “Precision Xtra™ Blood Glucose and Ketone Monitoring System

II. Equipment Needed for Cowside Blood BHBA Testing

1. Abbott Precision Xtra™ meter

These meters retail are available from most veterinary distributors for about \$50. Most human pharmacies also stock the meters, but they typically retail for about \$75 to \$90. Sometimes the meters can be found on sale at human pharmacies. Contact Abbott Animal Health Customer Service (888-299-7416) for updated information about veterinary suppliers of the meters.

2. Abbott Precision Xtra™ Blood Ketone test strips

The blood ketone test strips (which measure BHBA) are sold in boxes of 10 strips each. Expect to pay about \$13 to \$15 for a box of 10 strips (\$1.30 to \$1.50 per strip) through a veterinary distributor. Contact Abbott Animal Health Customer Service (888-299-7416) for updated information about veterinary suppliers of the blood ketone test strips. Most human pharmacies do not stock the blood ketone strips routinely but can order them. Expect to pay about \$40 to \$75 for a box of 10 strips (\$4.50 to \$7.50 per strip) if purchased through a human pharmacy or on-line human pharmacy distributor.

Spending \$1.50 per BHBA test is cheaper than sending a blood sample to a lab for BHBA testing, but more expensive than cowside urine or milk tests. Cowside urine and milk tests are not as accurate as the blood tests.

If you find the blood ketone strips at a very cheap price (eBay, other web vendors) then they may be very short-dated or even out of date. Out of date strips cannot be used - the meter will give an error message and will not display a ketone reading.

III. How to Use the Cowside Blood BHBA Test in Cattle

1. Remove a ketone test strip from its foil packet and insert it into the meter (with the contact bars on the test strip facing up). The meter will automatically turn itself on, recognize the lot number of the test strip, and prompt you that it is ready for the blood sample to be applied to the end of the test strip. Make sure that the displayed lot number on the meter is the same as the lot number on the test strip. Note that you must put the ketone calibrator strip (one of these is provided in each box of 10 strips) into the meter the first time you use a test strip from a new box of 10 test strips. The meter then “remembers” this lot of test strips and recognizes them automatically when they are placed in the meter. No further calibration of the meter is necessary.

Be sure to keep the ketone test strip dry before using it. Moisture on the test strip may falsely lower the BHBA test results.

Note that you must put the test strip into the meter before applying blood to it.

2. Obtain a drop of blood from the cow. The best way we have found to do this is to collect a very small amount of blood from the tail vein using a small needle (20 or 22 gauge) and small syringe (1 ml tuberculin syringe or a 3 ml syringe). You only need a good flash of blood in the syringe (<0.1 ml) and you have the entire sample you need. Cows that are lying down often don't even get up when you insert such a small needle in the tail vein.
3. Apply a drop of blood from the syringe to the end of the test strip. The strip will draw the blood into a small sample well, and the meter will indicate when the sample well is full. The amount of blood needed is very small (1.5 microliters).
4. Wait 10 seconds for the meter to display the results (it will count down the time). BHBA results are displayed as mmol/L (same as millimoles/liter or mM). To convert from mmol/L to mg/dL, multiply the test result by 10.3. So, a test result on the meter of 1.4 mmol/L equals 14.4 mg/dL. Published literature suggests that between about 1.2 and 1.4 mmol/L BHBA is the threshold level at which cows begin to show problems due to ketosis (reduced milk yield and/or higher risk of secondary diseases). Because the meter gives slightly lower test results than serum tests done at a laboratory and because we don't want to misclassify cows that may have ketosis as being normal, we recommend classifying all cows with 1.2 mmol/L or higher BHBA concentrations as having ketosis.
5. We have found that this small, hand-held meter works very well cowside. It is not necessary to bring the blood samples inside. If it is cold outside be sure to keep the meter and test strips warm in your pocket.

III. Accuracy of the Cowside Blood BHBA Test

Even using the human blood calibration inherent in the ketone monitoring system, the BHBA results on blood from cattle are surprisingly accurate. The first report about the application of this meter to cattle was an abstract in the *Journal of Dairy Science* (JDS 87:114, Suppl.1, 2004). No accuracy information was included in this abstract, although in the oral abstract presentation the authors presented data indicating that the ketometer BHBA values were very similar to commercial laboratory BHBA test results. A later Danish abstract from the 2006 World Buiatrics Congress indicated that BHBA results from the ketometer (marketed by Abbott in Europe as the MediSense® system) were highly correlated to laboratory test results for BHBA ($R^2 = 0.987$).

Three recent research studies reported as research abstracts from the AABP convention (Heuwieser et al., AABP Proceedings 40:253, 2007; Burke et al, AABP Proceedings 41:287, 2008; and Oetzel and McGuirk, AABP Proceedings 41:234, 2008) all gave very similar results and all confirm the excellent accuracy of the Precision Xtra™ blood ketone system for diagnosing ketosis in dairy cattle. These studies involved a total of 622 cows with a 14.1% prevalence of ketosis. The average R^2 between hand-held meter and laboratory BHBA results was 0.94. The hand-held meter was 91% sensitive and 94% specific for diagnosing ketosis (pooled results from all three trials). The positive predictive value for the meter was 73% and the pooled negative predictive value was 98%.

These results are extremely encouraging and suggest that BHBA results from the hand-held meter are excellent – far better than the other cowside tests (urine acetoacetate or milk BHBA) that are currently available.

It should be noted that the hand-held meter is not sufficiently accurate for research purposes (Kaiser et. al, *Journal of Dairy Science* 92 E Suppl-1:478, 2009). This is particularly true in research studies evaluating small changes in blood BHBA that fall below the ketosis threshold.

IV. Application of the Cowside Blood BHBA Test in Practice

The most rewarding use of cowside blood BHBA testing is for herd-based ketosis monitoring. Strategies for herd-based testing are explained in detail in the review article entitled “Monitoring and Testing Dairy Herds for Metabolic Disease” (*Veterinary Clinics of North America: Food Animal Practice, Managing the Transition Cow to Optimize Health and Productivity*, W.B. Saunders Co., Philadelphia, PA, 20(3):651-674, 2004). The cowside BHBA test with the hand-held meter can be used in place of submitting serum or plasma samples to a laboratory for BHBA testing. In summary, the protocol involves testing 12 or more cows in early lactation. If more than 10% of the cows tested have elevated blood BHBA, then the group is considered to have a ketosis problem.

The advantages of using cowside blood BHBA testing for herd-based monitoring (instead of submitting samples to a laboratory) are obvious. Cost of the ketone test strips are less than the cost of laboratory testing, the results are known immediately, only a very small blood sample is required, and there is no need to process or mail serum or plasma samples to a laboratory.

The cowside blood BHBA test can also be used to test individual cows for ketosis. Cowside blood BHBA information can then be used for individual cow treatment decisions. Other

cowside tests (milk BHBA or urine acetoacetate) have been traditionally used for this purpose. The cowside blood BHBA test has much better combined sensitivity and specificity than the other cowside tests. However, the blood BHBA test is more expensive and requires some skill in sample collection and some training to learn to operate the meter. The choice of the best protocol for individual cow ketosis testing depends on the unique circumstances within each dairy herd.

V. Comments about Cowside Blood Glucose Testing

There may be some usefulness for cowside blood glucose testing. The test strips for whole blood glucose for the Abbott Precision Xtra™ meter are readily available (usually in stock at most pharmacies), cost less than \$1.00 each, and are as easy to use as the blood ketone strips. However, agreement between laboratory plasma glucose and whole blood glucose using the cowside test is not as good as it is for BHBA. We compared blood glucose determined by the hand-held meter compared to laboratory analysis and found an R^2 of 0.56 (Oetzel and McGuirk, AABP Proceedings 41:234, 2008). The hand-held meter with glucose strips was about 55% sensitive and 99% specific in diagnosing hyperglycemia (blood glucose >79 mg/dl).

We suggest that cowside blood glucose testing be used only for individual cow treatment decisions and not as a herd-based monitoring test. Glucose is not useful as a herd-level test because it is a highly regulated metabolite that is unlikely to change in response to overall herd management or nutrition. Also, the necessary cut points and alarm levels for herd-based glucose testing have not been derived. Herd-level problems with energy nutrition are diagnosed by monitoring blood BHBA in the fresh cows, milk yield and body condition score for the rest of lactation, and blood nonesterified fatty acids (NEFA) in the pre- and post-fresh cows.

We have found that blood glucose is consistently low in cows at the time of their first ketosis diagnosis, even if the cow is in very early lactation and apparently has Type II ketosis with underlying fatty liver. Thus it is not necessary to confirm the hypoglycemia before treating these cows with an oral glucose precursor or IV glucose.

There are many situations involving individual sick fresh cows where their glucose status is uncertain and some information about their blood glucose status could guide treatment decisions. We are particularly concerned about avoiding glucose treatment in cows that are already hyperglycemic. Situations in which glucose testing could be useful include chronically ketotic cows (particularly following multiple ketosis treatments), any sick cows that are less than about 4 days in milk (these cows are often hyperglycemic because they calved so recently), and off-feed cows without an obvious cause. In these situations, knowledge of the cow's glucose status would be valuable prior to treatment. Treating cows with IV glucose (or over-treatment with oral glucose precursors) can have negative consequences and should not be undertaken in cows that are already hyperglycemic. For example, the hand-held meter could be used to show that routine treatment of just fresh cows with IV glucose is unnecessary and contraindicated because these cows are already hyperglycemic. Veterinarians or producers that already use the meter for blood BHBA determinations may find it useful to purchase some blood glucose test strips and use them for occasional blood glucose testing.