



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 for about \$70 (USD), but you can often find them on sale for as little as \$10 to \$20. Most pharmacies stock them, and many online vendors carry them (for example, <http://www.medmarketplace.com/> or <http://www.medexsupply.com>).

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 \$40 for a box of 10 strips, or \$4.00 per test. This is cheaper than sending a blood sample to a lab for BHBA testing, but more expensive than cowside urine or milk tests.

Most pharmacies do not stock the blood ketone strips routinely but can order them for you. We did hear of one DVM finding the ketone test strips in stock at a Wal-Mart store. Many online vendors carry the strips as well (e.g., <http://www.medshopexpress.com/>; <http://mednet-store.stores.yahoo.net/>; <http://www.cvs.com/>; <http://www.walgreens.com/>, etc.).

Make sure you are ordering the blood ketone strips (10 per box) and not the Precision Xtra™ glucose strips (usually 50 or 100 per box, and usually less than \$1.00 per strip).

If you find the blood ketone strips sold as 8 strips per box, then you are getting the older version of the ketone strips. They may be outdated.

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. The meter may give you an error message if you try to use outdated strips in it.

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.

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 (25 or 27 gauge) and syringe (1 ml – tuberculin syringe). You only need a good flash of blood in the syringe (<0.1 ml) and you have all the 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.

Note that lancets for human use do not appear to work in cattle. A cow's skin is too thick, even in the tail fold area.

Some have suggested placing a needle alone in or near the tail vein area, withdrawing the needle, and then holding the test strip (attached to the meter) up to the resulting drop of blood. This could work, although we prefer to keep the meter away from the cow's rear end, and we don't want to contaminate the blood sample with dirt or manure.

3. Apply a drop of blood from the syringe (leaving the needle on) 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. Cows that are 1.4 mmol/L or higher are considered positive for ketosis.
5. We have found that this small, hand-held meter works very well cowside. There is no need to bring the blood samples inside. If it is very cold outside (<10°F) be sure to keep the meter 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 ($R^2 = 0.987$). A German abstract presented at the 2007 AABP conference (these proceedings are in press) also indicated that BHBA results from the hand-held meter were highly correlated to laboratory results (R^2 was about 0.91). The sensitivity and specificity of the hand-held meter in detecting ketosis was very high - about 85 to 98%, depending on the ketosis threshold chosen.

Our own preliminary work comparing BHBA results with the hand-held meter to laboratory results agrees with these previous studies. Our initial data (112 comparisons) indicate an R^2 of about 0.90, sensitivity of >85%, and specificity of >97% using a ketosis threshold of blood BHBA ≥ 14.4 mg/dl. We are actively collecting more data and will report final results later.

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. In fact, results from the meter are very little different than sending blood serum or plasma samples to a laboratory.

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 blood BHBA ≥ 14.4 mg/dl (1.4 mmol/L), 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 the other cowside tests. However, the blood BHBA test is more expensive and requires more skill and training to operate than the milk or urine tests. 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. Our preliminary results suggest an R^2 of about 0.60. This allows for identification of cows with rather high or low blood glucose concentrations, but leaves uncertainty about mid-range values.

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. And even if blood glucose somehow is a biologically relevant herd monitor, its necessary cut points and alarm levels for herd-based 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-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. These situations 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 glucometer 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.