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Evaluating machine and technician effects on ultrasonic measures of backfat and longissimus muscle depth in swine

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Summary

Objective: To compare the accuracy of A-mode versus B-mode ultrasound in measuring last-rib backfat, tenth-rib backfat, and tenth-rib longissimus muscle depth.

Procedure: Twenty-seven market pigs were measured by three different technicians using five different A-mode ultrasonic machines. Measures included tenth-rib fat depth, tenth-rib longissimus muscle depth, and last-rib fat depth measured at the C and K positions. B-mode measures were collected by a National Swine Improvement Federation-certified technician as the standard for comparison.

Results: For last-rib fat depth, the effects of machine and pig were highly significant ($P \leq .001$). However, the interaction between machine × pig was also significant ($P \leq .01$). Pig and machine × pig interactions may be explained by overestimating C and K for leaner pigs and underestimating C and K for fatter pigs. At the tenth rib only, the effect of machine was significant ($P \leq .001$). For longissimus muscle depth, machine was highly significant ($P \leq .001$) and a tendency ($P \leq .1$) for the effects of technician and technician × machine interaction was observed.

Implications: The accuracy of the estimation of both fat and longissimus muscle depth varies among ultrasound machines, which should be considered when making the decision to purchase ultrasonic equipment.

Keywords: swine, ultrasound, carcass

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Ultrasonic measurement is routinely used to predict fat and muscle depth in swine. Researchers began using ultrasound 40 years ago to determine live animal composition.[1,2] Because carcass value programs have become the predominant pricing system for marketing swine, there has been a recent surge of interest among producers in ultrasonography. Indeed, the demand for training in this technology has prompted the National Swine Improvement Federation to sponsor ultrasound certification schools.[3] Ultrasonic measures can also help the commercial producer determine the lean gain patterns of swine to further refine feeding programs. Fat depth measures can play an important role in condition scoring the sow herd to enhance management and nutrition practices. Operations that produce and retain their own replacement gilts may also use ultrasonic measures of backfat for a selection criteria.

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Much of the recent research with ultrasound has been conducted using brightness-mode (B-mode) instruments, with multi-element linear probes that produce two-dimensional cross-sectional images of the body. B-mode ultrasonic equipment can produce a continuously changing or "real-time" ultrasound image that can be frozen or captured.[4] B-mode ultrasound backfat values taken immediately prior to slaughter have been reported to be highly correlated with carcass values.[4,5] It has also been reported that B-mode equipment was better at determining lean meat percentage on live pigs[6] than amplitude-mode (A-mode) ultrasound machines, which generally use a single transducer in a single-point estimation of depth. Therefore, B-mode ultrasound is currently considered the industry standard for live animal evaluation. However, A-mode ultrasonic equipment is generally less expensive, more durable, and more portable than B-mode equipment.

There has been no research to evaluate recent improvements in A-mode ultrasound technology. The objective of this study, therefore, was to examine the accuracy of various A-mode ultrasound machines, as compared to B-mode ultrasound, for measurement of last-rib backfat, tenth-rib backfat, and tenth-rib longissimus muscle depth and to evaluate technician × machine interactions.

Materials and methods

Twenty-seven market pigs of a uniform genetic source were visually selected for maximum variation in fat depth. The 15 barrows and 12 gilts averaged 112 kg (246 lb) live weight. The following measurements were made on all pigs:

- tenth rib fat depth ("tenth") at a location 18 cm (7.1 inches) in front of the last rib and 7 cm (3 inches) from the dorsal midline;
- longissimus muscle depth ("loin depth") at a location 18 cm (7.1 inches) in front of the last rib and 7 cm (3 inches) from the dorsal midline;
- Last rib fat depth was measured at the "C" and "K" positions. The last rib was located by palpation; C was measured at a location 5 cm (2 inches) from the dorsal midline; and K was measured at a location 7.5 cm (3.0 inches) from the dorsal midline.

All pigs were measured by three different technicians using five different A-mode ultrasonic machines (Table 1). Measurement sites were independently determined by each technician. Two technicians had previously attained National Swine Improvement Federation certification for ultrasound backfat measurement. The third technician had previously had a moderate amount of experience with ultrasound. No technician had previously used all five machines.

Measurements of loin depth and tenth-rib fat thickness were not made on two of the machines (Machines 1 and 2) due to machine limitations.

After all measurements were completed by each technician, pigs were evaluated with B-mode ultrasound as the standard for comparison. The B-mode measurements were made by a fourth technician who was certified by the National Swine Improvement Federation. B-mode measures of C, K, tenth-rib and loin depth were taken at the same positions as those taken in the A-mode measurements using an Aloka 500V ultrasound unit (Corometerics Medical Systems, Wallingford, Connecticut) (Table 1). Each of the four technicians was responsible for independently locating the measurement positions as defined.

Statistical analysis

General linear model procedures were used to analyze the accuracy of ultrasound measures for the 27 pigs, three technicians, and five machines against the standard of B-mode measurements.[7] The absolute values of the difference between the A-mode ultrasound and B-mode ultrasound measurements were analyzed with fixed effects for:

- technician,
- machine, and
- technician × machine interaction;

and the random effects of:

- pig,
- pig × technician interaction, and
- pig × machine interaction.

Accuracy of ultrasound measure was also described by the rank correlation between A-mode and B-mode measurements on the same pig.

Bias — a measure of the average deviation from the B-mode standard — was also calculated as a measure of accuracy. Bias was estimated as:

$$\Sigma_i \Sigma_k ((\text{A-mode}_{ijk} - \text{B-mode}_i) \div N{\bullet\bullet}k$$

where:

A-mode$_{ijk}$ is the measure taken with the kth machine by the jth technician on the ith pig,
B-mode$_i$ is the B-mode estimate for the ith pig, and
N••k is the number of pigs scanned with the kth machine.

Results

The measurement of the four positions varied depending upon the machine, technician, and pig (Figure 1).

Machine accuracy

For all ultrasonic measures, machine 3 was the least accurate compared to the B-mode standard (Figure 2). However, the machines varied in their accuracy compared to the B-mode standard.

For measures of fat depth at the last rib, machine 1 was significantly ($P \leq .001$) less accurate than machines 2, 4, and 5 (Figure 2). Bias calculations indicate that machines 1, 2, and 5 underestimated fat depth at the last rib while machines 3 and 4 tended to overestimate fat depth at the last rib (Figure 3). For measures of loin depth, machine 5

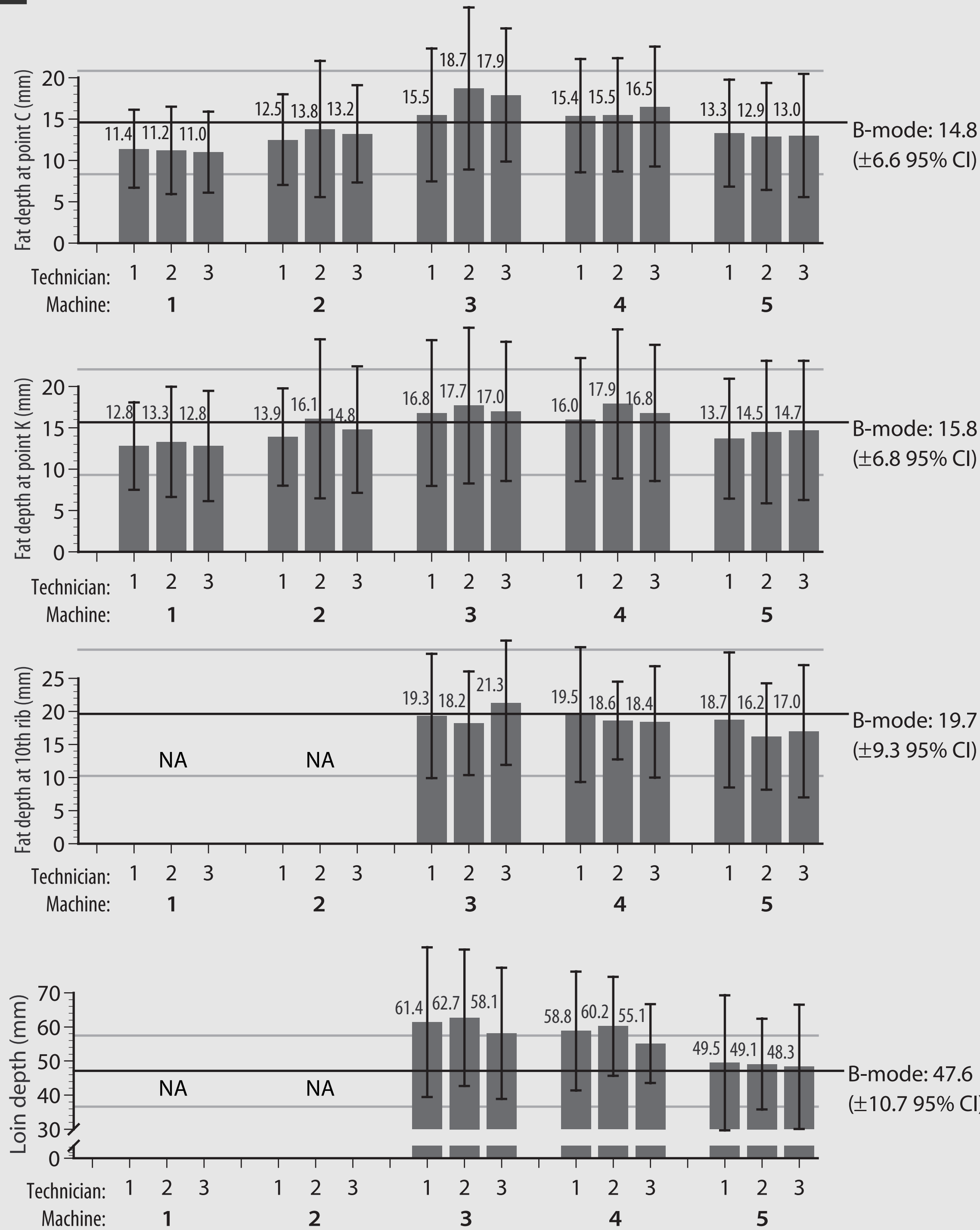
Table 1

A-mode ultrasonic devices

No.	Machine (manufacturer)	Measures evaluated: C	K	10th	Loin depth	Can log data
1	Lean-meter — 2-layer mode (Renco Corporation, Minneapolis, Minnesota)	✓	✓			
2	Lean-meter — 3-layer mode	✓	✓			
3	Sono-Grader (Renco Corporation, Minneapolis, Minnesota)	✓	✓	✓	✓	✓
4	A-Scan Plus (Sonic Industries, Hatboro, Pennsylvania; distributed by Osbourne Industries, Osbourne, Kansas)	✓	✓	✓	✓	✓
5	Piglog 105 (SFK, Soborg, Denmark; distributed by AmeriScan Technologies Corporation, Peosta, Iowa)	✓	✓	✓	✓	✓
B-mode (reference)	Aloka 500V (Corometerics Medical Systems, Wallingford, Connecticut)	✓	✓	✓	✓	✓

Machines 1 and 2 are the same machine with a switch placed in position to read either two or three fat layers. They can measure only fat depth.

Figure 1

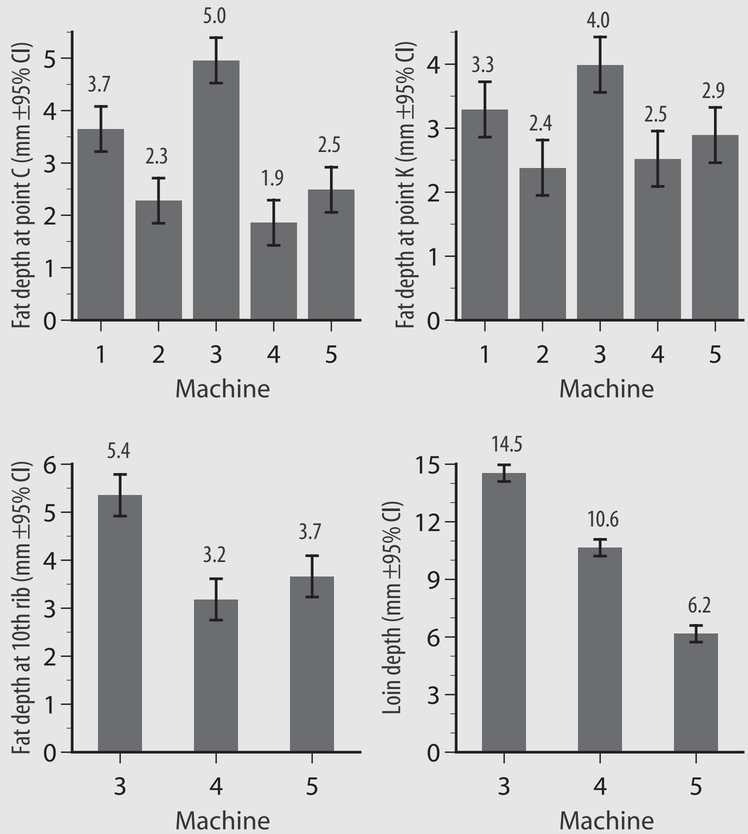


Means and 95% confidence intervals by technician and machine for ultrasonic measurements

was the most accurate. Machines 3, 4, and 5 were significantly different ($P \leq .01$) for accuracy of loin depth measurement. The correlation coefficients for measures of C between A-mode and B-mode ultrasound ranged from 0.11 ($P > .1$) to 0.78 ($P \leq .001$); machine 4 was the most accurate followed by machine 2 and machine 1. For measures of K, machine 2 was the most accurate closely followed by machine 4 and machine 1.

Compared to B-mode ultrasound, it appears that machines 1, 2, and 5 consistently underestimated fat measurements (Figure 3). Machines 3, 4, and 5 consistently overestimated loin-depth measurements. All machines overestimated loin depth.

Figure 2



Least-squares means by machine for absolute difference between A-mode ultrasound and B-mode ultrasound measurements

Technician accuracy

For the absolute difference (least squares means) between A-mode and B-mode ultrasonic fat depth at the tenth rib, only the effect of machine was significant ($P \leq .001$). For the absolute difference between A-mode and B-mode loin depth, the effect of machine was highly significant ($P \leq .001$) and the effects of technician ($P \leq .05$) and technician × machine interaction were significant ($P = .08$) (Figure 4).

The poorest degree of accuracy for measuring loin depth was obtained with machine 3 by all technicians. When ranked on loin depth within technician, all machines ranked the same for accuracy. However, across technicians there tended to be a machine × technician interaction ($P = .08$). Technician 3 was the most accurate with machines 3 and 4 and technician 2 was the most accurate with machine 5. However, all technician × machine combinations tended to overestimate loin muscle depth as compared to B-mode (Figure 4). Technician 3 consistently had the smallest bias across all machines. However, correlation coefficients between A-mode and B-mode loin depth measures indicate that technician 2 was the most accurate in ranking animals on loin muscle depth with machine 4 and machine 5.

Pig variability

For the absolute difference between A-mode and B-mode, the effects of pig (Figure 5) were highly significant for measures taken at the C and K positions ($P \leq .001$). The interaction between machine × pig was also significant ($P \leq .01$).

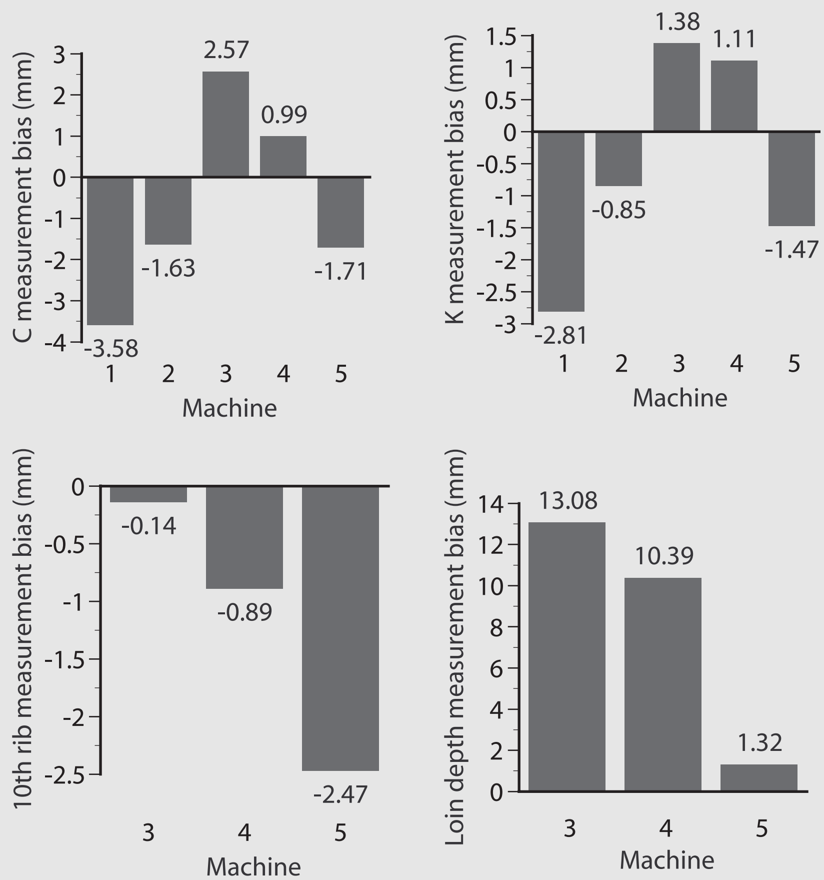
Discussion

Overall, we found that A-mode ultrasonography yielded measurements that sometimes significantly differed from the B-mode standard. Machine, technician, and pig were all significant factors for these differences. The small bias combined with the low correlation with B-mode for the tenth rib fat measurement reported on machine 4 could be interpreted as random misses both high and low.

The tendency for technician × machine interaction agrees with previous research using A-mode and B-mode ultrasonic equipment, where the evaluation of the longissimus muscle is much more dependent on the training and qualifications of the technician.[4,8,9]

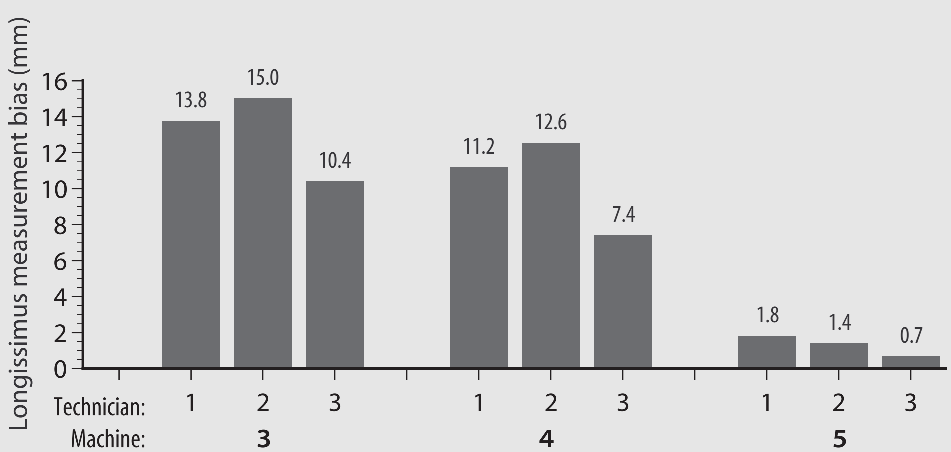
Significant pig and machine × pig interactions may be explained by the overestimations of C and K for leaner pigs and underestimations of C and K for fatter pigs (Figure 5), where the deviation between the A-mode and B-mode measurements was plotted against the actual B-

Figure 3



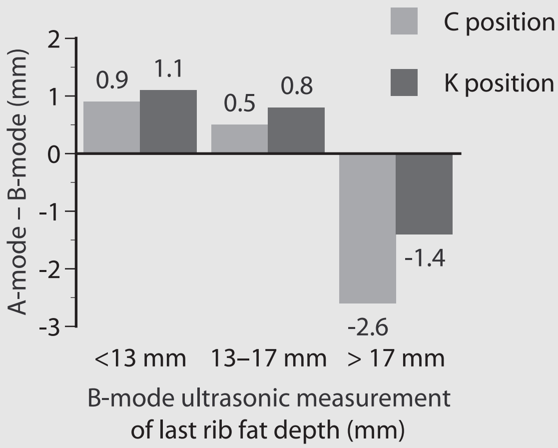
Bias by machine of accuracy of ultrasound fat and longissimus muscle depth; 0 = B-mode measurement standard
Bias = $\Sigma_i \Sigma_k$ ((A-mode$_{ijk}$ – B-mode$_i$) ÷ N••k where A-mode$_{ijk}$ = measure taken with the kth machine and jth technician on ith pig; B-mode$_i$ = B-mode estimate for ith pig; and N••k = number of pigs scanned with the kth machine

Figure 4



Bias by machine and technician of accuracy of ultrasound longissimus muscle depth; 0 = B-mode measurement standard
Bias = $\Sigma_i \Sigma_k$ ((A-mode$_{ijk}$ – B-mode$_i$) ÷ N••k where A-mode$_{ijk}$ = measure taken with the kth machine and jth technician on ith pig; B-mode$_i$ = B-mode estimate for ith pig; and N••k = number of pigs scanned with the kth machine

Figure 5



A-mode ultrasonic measures of last rib fat minus B-mode measures of last rib fat depth plotted against B-mode ultrasonic measures of last rib fat depth

mode measurements. These results indicate that in our study, there was a greater potential to underestimate C and K fat depth with A-mode machines. A-mode ultrasonic machines have previously been found to underestimate backfat, relative to carcass measurements.[10]

Implications

- Machines 2, 4, and 5 were the most accurate for estimating fat depth at the tenth and last rib.
- Machine 5 was found to be the most accurate for estimating longissimus muscle depth at the tenth rib.
- When deciding to purchase ultrasonic equipment, additional factors such as service, reliability, durability, ease of operation, and price should also be considered.

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