DETERMINATION OF LONGISSIMUS MUSCLE AREA IN PIG WITH ULTRASONIC LINEAR ELECTRONIC SCANNER

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Summary

The usefulness of a portable linear electronic scanner, B-mode ultrasonic machine, was evaluated for estimating the longissimus muscle area from ultrasonic measurement of the muscle depth in 22 live pigs. The electronic scanner was easy to operate for muscle measurements in live pigs, which did not have to be held but were caged. The cross-sectional images of longissimus muscle and covering muscles and fat appeared on the monitor with grey scale in real time. It was easy to identify the ultrasonograms of fat and muscular tissues because the images differed in the degree of the grey scale. The longissimus muscle had less echogenic image than the other muscles. The boundary lines between first, second or third layers of backfat and the longissimus muscle were distinct on the ultrasonogram. The ultrasonic measurement at the shoulder was not acceptable because of the unstable measurements and the complex tissue structure. The repeatabilities for the measurements of longissimus muscle depth at one-half body length and last rib were acceptable. The simple correlation coefficients between ultrasonic estimates of the muscle depth in live pigs and the actual areas in the carcass, were 0.50 and 0.55 at the last rib and the one-half body length, respectively. Therefore, those positions were similarly suitable to measure. The method of electronic scanner for determining longissimus muscle area from the muscle depth was suitable for practical use in the field because of the simple and inexpensive technique.

(**Key Words**: Pigs, Ultrasonics, Longissimus Muscle, Loin Area, Linear Scanner)

Introduction

Ultrasonic techniques have been used to live animals for different purposes. Recently, various types of ultrasonic apparatus have developed. Using an ultrasonic B-mode electronic linear scanner to pig, Irie et al. reported on its use for pregnancy diagnosis (Irie et al., 1984), measurement of backfat thickness (Irie and Nishimura, 1987) and so on (Irie and Nishimura, 1986; Irie, 1987). Our methods, especially pregnancy diagnosis, is spreading to scientists, veterinarians and farmers in Japan. As the ultrasonic scanners become cheaper, it could be more widely used for a variety of purposes.

The longissimus muscle area, which is commercially important, has been adopted as a selection trait of breeding pig. Its measurements in Japan is determined with a mechanical sector scanner. A transducer of the mechanical scanner moves mechanically along a metal guide attached to pig's back for five seconds. The pig is needed to keep still for good ultrasonogram and sometimes is bounded. A portable electronic linear scanner, in comparison with mechanical sector one, has some advantages: simple operating, inexpensive price, scanning speed and so on.

The purpose of the present experiment was to investigate simple techniques for determination of longissimus muscle area with the electronic linear scanner.

Materials and Methods

The 22 female and male Landrace pigs born in our research center were used in this experiment. Live weight averaged 104.6 kg (S.D. = 10.7).

The ultrasonic measurements were taken with B-mode linear electronic scanner (U sonic Mini, Model RT-50, Yokogawa Electronic Company, Japan), which was the same used in our previous reports (Irie et al., 1984). The scanner equipped with 3.5 MHz transducer was width 23.0 cm,

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length 35.2 cm, height 17.8 cm and weight 5.5 kg. Ultrasonic image of width 8.5 cm and depth 16.5 cm appear on the 5.5 inch monitor in real time. Since the scanner was portable and not expensive, the method of measuring longissimus muscle area was considered practical for use in the field. When the ultrasonic measurements was made, each animal was caged in a weight scale but not bounded. The animals were scanned in a standing position. Ultrasonic contact reagent or water was utilized as a conduction medium between the skin and the transducer; the hair was not removed. When the pigs straightened up their body, instant photographs were taken at the following positions. The transducer were placed over the longissimus muscle on the left side at shoulder, one-half body length and last rib. The shoulder position suggested by Jinbu et al. (1983) was about on the 5-6th rib, which is a cutting position of the carcass for progeny test. The one-half body length is a measuring position by ultrasonic method for direct test of boar selection in Japan. The last rib position have been adopted in many researchers.

After recording the ultrasonic measurements, the pigs were marked with a little lipid dye

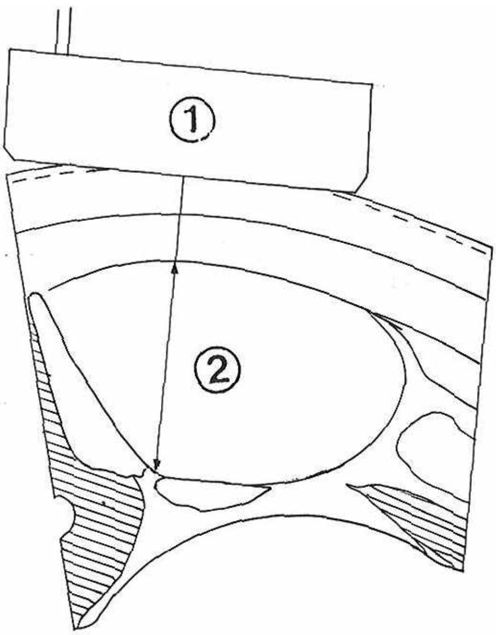

Figure 1. Diagram showing transducer position (①) and depth on longissimus muscle (②).

solution so the location of measurements could be identified precisely on the carcass. Ultrasonic measurements were taken on the photographs by modified method based on muscle depth (Ramsey et al., 1972). In this study, one end of the transducer was located at dorsal midline (figure 1). The muscle depth was measured on a line perpendicular to the line of skin from the boundary between fat layers and longissimus muscle to the deep point of the muscle near the vertebrae. All interpretation of scans and areas were performed by a single operator.

The pigs were held off feed for 24 hr but had to access to water. After animals were slaughtered, the carcasses were chilled for 24 hr. The carcasses were cut at three positions with the mark and at 5-6th rib. The longissimus muscle areas were traced on the papers and measured with a planimeter.

Repeatability of ultrasonic variables as defined by Mersmann (1982) and the correlation coefficients between ultrasonic and carcass variables were calculated.

Results and Discussion

Operating of Electronic Linear Scanner

This machine equipped with a power switch and a gain dial for contrast, was easy to operate. The method of operation was to switch on the machine and to contact the body with the transducer. The scanner needed no adjusting. For growing-finishing pigs without bounding, good ultrasonograms were got instantly after moistening beforehand with water or contact reagent. The operator needed to make sure that the pigs posture was normal before the ultrasonogram was recorded. Some movement of pig tended to change a shape of the muscle on ultrasonogram. Giles et al. (1981) reported that the method of restraint had a small effect on the accuracy of scanogram prediction of longissimus muscle area.

The both edges of ultrasonogram were occasionally missed, because the linear array transducer always did not fit the body line of pig. To avoid missing the longissimus edges, the transducer needed to be pressed on the back of pig. However, too much pressure was not desirable because it changed the shape of the tissue or excited the pig.

In the present study, the method that the muscle outline on ultrasonic image is traced on a paper and measured for the area was not adopted. Although the outline method is adopted for ultrasonogram with mechanical scanner, it will take a long time. Another reason was that whole image of longissimus muscle could not appeared on one screen of the monitor at the same time. However, for field use, the electronic scanner has the advantage that the images appear in real time whereas with the mechanical scanner it is necessary to take several seconds. The B-mode scanners seem preferable to the A-mode type for measuring longissimus depth because muscle and adipose tissue structure could be more easily interpreted from the ultrasonograms produced by the B-mode. Glodek (1988) reported several disadvantages of the B-mode scanners including higher purchase and operating costs, difficulties in making adjustments, the small screen size and problems in preventing the pigs from moving while readings were being taken. The B-mode scanner we tested did not have these problems. In Japan, even the price of the B-mode scanner was similar to that of A-mode machines showed by Glodek (1988).

Interpretation of Ultrasonic Images

Ultrasonograms, diagrams and photographs of longissimus muscle in pig at different positions are shown in figures 2-4. Interpretation of images of fat layers was described in our previous report (Irie and Nishimura, 1987). Skin was a white image, which is called to be highly echogenic. On the contrary, "non-echogenic" means "black." The first and second layers of backfat had a similar low grey scale value. The connective tissue sheets between both fat layers always provided good ultrasonic reflections showing as distinct lines on the ultrasonograms. The third layer of backfat was highly echogenic, and longissimus muscle was slightly echogenic as at similar levels as first and second layers of backfat. Therefore, the boundary of them was easy to distinguished. When the ultrasound was reflected from the rib, no images could be gained below the muscle. At the last rib position, a kidney was often observed below the muscle where there is no born. The boundary beneath the longissimus muscle was not always distinct.

Images with the grey scale differed a little between muscles. In some cases, the differences

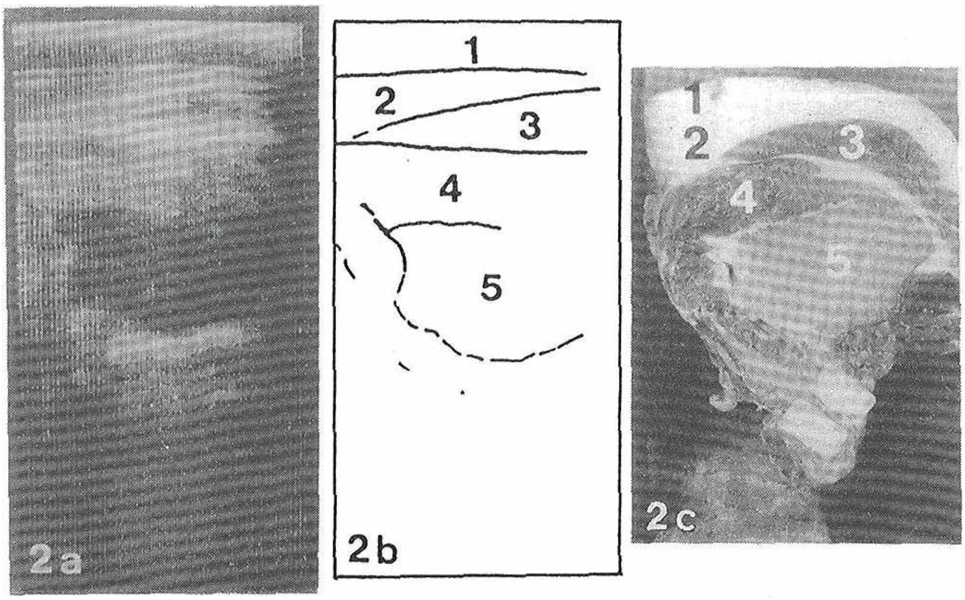

Figure 2. Cross section at the shoulcer. Figures 2a, 2b and 2c are the ultrasonogram, the diagram and the photograph of cross sectional cut, respectively, at the 5th-6th rib of pig. 1, First layer of backfat ; 2, Second layer of backfat ; 3, M. trapezius ; 4, M. spinalis ; 5, longissimus muscle.

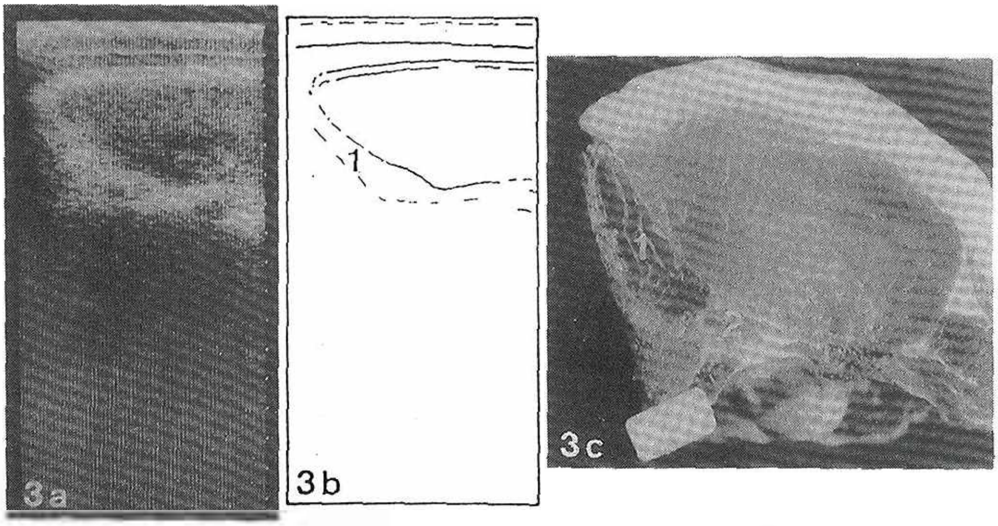

Figure 3. Cross section at the one-half body length. Figures 3a, 3b and 3c are the ultrasonogram, the diagram and the photograph of cross sectional cut, respectively. 1, M. multifidus ; 2, M. intertransversarius ; 3, longissimus muscle.

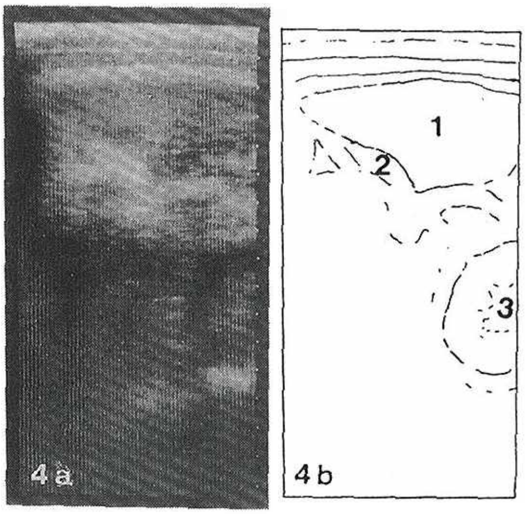

Figure 4. Cross section at the last rib. Figures 4a, 4b are the ultrasonogram and the diagram, respectively.
1, longissimus muscle ; 2, M. multifidus; 3, kidney.

were not clear. The longissimus muscle was a little less echogenic than M. trapezius and M. spinalis, and less than M. multifidus and M. intertransversarius. However, the boundary between the last two muscle was not be distinct.

The M. multifidus differed in ultrasonograms between the electronic linear one with grey scale in the present study and the mechanical are scanner used by Miyazawa et al. (1977). With the linear scanner we tested, the image of the M. multifidus muscle was highly echogenic. Miyazawa et al. (1977) reported that image of the M. multifidus with are mechanical scanner was non-echogenic because the ultrasonic waves of incident were parallel to the muscle bundle and hard to reflect.

Ultrasonograms at one-half body length and the last rib were more distinct than those at the shoulder. The complexity of tissue structures and greater depth of the muscle at the shoulder made it difficult to separate the different tissue on the ultrasonograms. Because of clearer distinctions between tissue boundaries, it is obvious that the position of one-half body length and last rib were suitable for measuring than shoulder position.

Repeatability

Repeatability and simple correlation coefficients of ultrasonic variable of longissimus muscle area with linear electronic scanner are shown in table 1. The data in the table show that the duplicate longissimus muscle depth measurements were highly correlated and repeatable. High repeatability of ultrasonic measurements of longissimus muscle

TABLE 1. RELATIONSHIPS BETWEEN REPEATED MEASUREMENTS FOR ULTRASONIC VARIABLES OF LONGISSIMUS MUSCLE ON PIGS

Variables[1]	n[2]	Mean 1	SD	Mean 2	SD	Repeat[3]	r[4]
Shoulder	22	34.9	3.3	34.7	3.3	.86	.72
1/2 body length	22	38.1	4.1	38.2	3.8	.92	.83
Last rib	22	40.0	3.5	40.6	3.0	.94	.90

[1] Depth (mm). See figure 1 for abbreviations of position names.
[2] Number of animals.
[3] Repeatability obtained from one-way analysis of variance with each animal used as a treatment group. Repeatability = (δ^2 animal)/(δ^2 error + δ^2 animal).
[4] Simple correlation coefficients.

in the present study agreed with results of other reports (Lauprecht et al., 1960; Stouffer et al., 1961; Mersmann, 1982).

The results show that the scanner was able to take reliable measurements under the momentary conditions of pig restraint that were applied.

The measurement at the shoulder, however, was less repeatable than those at one-half body length and the last rib. For this reason and other reasons mentioned above, the shoulder position is not recommended for measurement. These results agreed with those of Mersmann (1982), who reported that the lower relationships probably reflect the more complex muscle and adipose tissue anatomy in the shoulder than in the mid-back region. Shoulder measurements change markedly as the pig moves.

Relations between Ultrasonic and Carcass Measurements

Ultrasonic and carcass measurements and their correlation coefficients are presented in tables 2 and 3, respectively.

The longissimus muscle depth obtained ultrasonically on a live animal was usually smaller than depth from carcass. The discrepancy averaged about 13 mm. However, it is now generally accepted that ultrasonic muscle depth measurements do not always correspond with the equivalent carcass measure. The present results agree with the authors (Mersmann, 1982; McLaren, 1989), who report that ultrasonic measurements were similar to corresponding carcass measurements or smaller than those. This underestimate may have been caused by echoes from boundaries above the lower surface of the longissimus muscle.

The correlation coefficients between the ultrasonic muscle depth in live pigs and the corresponding muscle area in carcass were 0.55 and 0.50, at one-half body length and last rib, respec-

TABLE 2. MEANS, STANDARD DEVIATIONS AND RANGES FOR CARCASS AND ULTRASONIC VARIABLES OF LONGISSIMUS MUSCLE ON PIGS

Variable[1]	n[2]	Mean	SD	Min. – Max.
Ultrasonic, muscle depth (mm)				
1/2 body length	22	38	4	31 - 44
Last rib	22	40	3	36 - 45
Muscle area (cm^2)				
5-6 thoracic vertebrae	22	23.0	4.8	17.0 - 35.3
1/2 body length	22	36.5	3.5	30.1 - 43.8
Last rib	22	36.2	3.2	30.0 - 43.2
Muscle depth (mm)				
1/2 body length	22	49	3	44 - 55
Last rib	22	50	3	45 - 57

[1] See figure 1 for abbreviations of position names.
[2] Number of animals.

TABLE 3. CORRELATION COEFFICIENTS BETWEEN ULTRASONIC AND CARCASS VARIABLES OF LONGISSIMUS MUSCLE ON PIGS

Variable	1.	2.	3.	4.
Ultrasonic, depth				
1. 1/2 body length				
2. Last rib	.70*			
Muscle area				
3. 5-6 thoracic vertebrae	.30	.25		
4. 1/2 body length	.55*	.44*	.71*	
5. Last rib	.48*	.50*	.55*	.76*

* $p < 0.05$.
n = 22.

tively. The values, which were significant and similar, were within the range of those reported by Ramsey et al. (1972) (r = 0.73 – 0.80), Stouffer et al. (1961) (r = 0.47) by the method of longissimus muscle depth, and Price et al. (1960) (r = 0.74), Stouffer et al. (1961) (r = 0.70), Gillis et al. (1972) (r = 0.46), Giles et al. (1981) (r = 0.46) and Mersmann (1982b) (r = 0.38 – 0.76) by the method of the muscle area.

At one-half body length and last rib, longissimus muscle depth was likely to be in proportion to the longissimus muscle area. The regressions for predicting longissimus muscle area from the muscle depth are:

One-half body length,

Longissimus muscle area (cm^2) = 0.51x (muscle depth, mm) + 16.8

The residual standard deviations (RSD) was 2.99.

Last rib,

Longissimus muscle area (cm^2) = 0.49x (muscle depth, mm) + 16.4

The RSD was 2.80.

Both the regression coefficients were similar at both positions. The one-half body length and rib positions were closely located, so the distance between them averaged 14.6 cm on the live body. The muscle areas were similar at the both positions in the same animal. Yano (1976) found that longissimus muscle areas varied in size between 5th and 10th rib but hardly between 11th rib and 2nd lumbar vertebrae in the same animal. Therefore, if those positions are not located actually on the live animal, similar values will be obtained. The one-half body length and the last rib can be used as suitable sites for measuring longissimus, muscle depth and area.

The present method of muscle depth with linear electronic scanner stand comparison with the method of muscle area, in accordance with Ramsey et al. (1972). Measurement of muscle depth had merits in terms of ease of the recording and saving of time and labour. In particular, the present method is suitable for farmers and breeders to apply in field.

In measurements of longissimus muscle depth, B-scanners have advantages in comparison with A-scanners. A-scanner have low accuracy and low repeatability for muscle measurements (Price et al., 1960b; Ritter et al., 1964), and the measurements need to be repeated (Ritter et al., 1964). Since it is difficult for users with A-mode machine to relate readings to anatomical features, uncorrected interpretations will be a feature from time to time. Busk (1989) found that the precision of prediction of meat percentage was only slightly increased by using the more advanced B-scanners compared to the A-scanners.

Based on the results of this study, a linear electronic scanner as tested in this trial will be useful to determine carcass trait in live pig.

Literature Cited

Busk, H. 1986. Testing of 5 ultrasonic equipments for measuring of carcass quality on live pigs. World Rev. of Anim. Prod. 22(3):35-38.

Giles, L. R., R. D. Murison and B. R. Wilson. 1981. Backfat studies in growing pigs. 2. A comparison of ultrasound and ruler probe predictors of backfat and eye-muscle measurements in the live pig. Anim. Prod. 32:47-50.

Gillis, W. A., G. H. Bowman, H. Greiger and G. W.

Rahnefeld. 1972. A comparison of ultrasonic with the ruler probe for the prediction carcass yield in swine. Can. J. Anim. Sci. 52:637-644.

Glodek, P. 1988. In Proceeding of the Meeting "Pig carcass and meat quality", (Ed V. Russo). Evaluation of carcass quality in live pigs. 43-60. Italy.

Irie, M. 1987. Observation on the uterus of postpartum sows via linear electronic scanner. Jpn. J. Zootech. Sci. 58:407-412.

Irie, M. and K. Nishimura. 1986. Observation of sows with reproductive defects by real time ultrasonic B-mode scan. Jpn. J. Zootech. Sci. 57:288-293.

Irie, M. and K. Nishimura. 1987. Ultrasonic measurement of backfat thickness in live pigs by the use of the B-mode linear electronic scanner. Jpn. J. Zootech. Sci. 58:44-52.

Irie, M., K. Ohmoto and S. Kumagaya. 1984. Diagnosis of pregnancy in pigs by real time ultrasonic B-mode scan. Jpn. J. Zootech. Sci. 55:381-388.

Jinbu, M., H. Nakai, T. Ikeda, S. Ando and K. Odutumi. 1983. Tyouonpa-keisoku-souti niyoru nikuton keisoku-bu no kentou. Jpn. J. Swine Sci. 20:197.

Lauprecht, E., E. Walter and T. Saathoff. 1960. Investigation on measurements of the musculus long dorsi and the back fat of live pigs with ultrasonic equipment. Zuchtunguskunde 32:450-464.

McLaren, D. G., F. M. McKeith and J. Novakofski. 1989. Prediction of carcass characteristics at market weight form serial real-time ultrasound measures of backfat and loin eye area in the growing pig. J. Anim. Sci. 67:1657-1667.

Mersmann, H. J. 1982. Ultrasonic determination of backfat depth and loin area in swine. J. Anim. Sci. 54:268-275.

Miyazawa, K., K. Kanno and M. Tanabe. 1977. Assessment of loin eye area of a live swine bodies with a scanner. Jpn. J. Swine Sci. 14:63-71.

Price, J. F., A. M. Pearson and J. A. Emerson. 1960. Measurements of cross-sectional area of the loin eye muscle in live swine by ultrasonic reflections. J. Anim. Sci. 19:786-789.

Ramsey, C. B., E. R. Lidvall and J. R. Conger, Jr. 1972. Estimating loin eye area in swine with a single ultrasonic measurement. J. Anim. Sci. 35:1160-1165.

Ritter, A., P. Schoen, F. Schelper and D. Fewson. 1964. On the accuracy of ultrasonic measurements in live pigs at different weight stages. Zuchtungskunde. 36:159-168.

Stouffer, J. R., M. V. Wallentine, G. H. Wellington and A. Dickmann. 1961. Development and application of ultrasonic methods for measuring fat thickness and rib-eye area in cattle and hogs. J. Anim. Sci. 20:759-767.

Yano, S., T. Ikeda and S. Ando. 1976. Determination of thickness of backfat and cross section area of longissimus thoracis in living bodies of swine. Jpn. J. Swine Sci. 13:1-6.