Developmental-Anatomical Observations on Cleavage Line Patterns of the Skin in Chinese Miniature Pigs

By

Hidekazu WAKURI, Jiwu LIU, Yaoxing CHEN and Ken-ichiro MUTOH

Department of Veterinary Anatomy, Kitasato University, Aomori 034, Japan and
1) Department of Veterinary Anatomy, Beijing Agricultural University, Beijing 100094, China

Key Words: Chinese miniature pig, Skin, Stab-wound, Cleavage line, Postnatal development

Summary: In twelve Chinese miniature pigs (CMP), of both sexes and ranging from newborn to 5 months of age, the postnatal developmental features of the cleavage lines of the skin of the whole body were examined by the stab-wound method, using a metal probe with a sharp conical point. 1). The CL patterns of the skin in the 5-month-old CMP were largely similar to those of adult Landrace-strain pigs (Wakuri et al., 1993). 2). At each monthly stage, the CL of the skin of the inter-ocular area, medial ocular angle, umbilicus, preputial orifice and anus presented a convergent arrangement. An annular pattern was found in the skin around the eye, the base of the ear, and the vulva. 3). Some alterations in CL patterns were seen during the general and regional growth of CMP, as shown in the skin of the lateral side of the trunk, the prepuce and the scrotum.

The skin of the various regions or areas of the living body is under local directional tension. The directions of this tension, which are called cleavage lines (CL), can be demonstrated (in dead animals) by producing stab-wounds in the skin.

The CL of the skin of the entire body surface in young and adult Landrace-strain pigs have been described by Wakuri and co-workers (1967, 1993). Other studies of CL include those of Gardner & Raybuck (1951), Irwin (1966) and Wakuri and co-workers (1961a, 1961b, 1986, 1987, 1990, 1992, 1994). In particular, prenatal and postnatal developmental alterations in CL patterns have appeared to be related to changes in body proportions as the animals grew older (Wakuri et al., 1994).

In the present study, the CL in twelve Chinese miniature pigs (abbr.; CMP, or Chinese miniature experimental pigs, commonly called Fragrant Pigs, Xiang pigs, or 'Xiang-Zhu' in Chinese, as described by Zhang et al., 1986 and ILAS-BAU, 1991), were examined in order to identify the postnatal development of the CL patterns and their likely morphological significance in CMP.

Materials and Methods

Twelve CMP (6 females, 6 males), from newborn to 5 months of age, were used (Table 1). The animals were premedicated with “Stress-nil”, at 0.1 mg/kg, anesthetised with a xylazine solution, at 0.06–0.1 mg/kg, injected with 20–50 ml of an anticoagulant solution and then exsanguinated through a canulated common carotid artery. They were perfused intravascularly with 5% formalin solution shortly before testing. In order to facilitate close observation of CL, in the newborn specimens the fine hairs were shaved, and in the older animals the ordinary hairs (i.e., bristles) of the skin were clipped. Sharpened conical instruments dipped in Chinese red dye were used to make clusters of perpendicular stab-wounds in the skin in each part of the body. The longer axis of each wound was taken as the CL. The directions of the CL were described in terms of their relationship to the long axis of the corresponding body-part, and the features of the CL of each animal were sketched and photographed.

Results and Discussion

General features of CMP are shown in Figs. 1 and 2. The ears were relatively small, but the pinna were prominent and approximately triangular. The skin was white, and the hairs all black and about 10–25 mm long in 5-month-old animals. Long primary hairs was present at the dorsal midline of the neck, on top of the tail and around the preputial orifice. Vibrissae occurred in the
Table 1. Chinese miniature pigs examined

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex</th>
<th>Age (month)</th>
<th>H &amp; B (cm)</th>
<th>BL (cm)</th>
<th>CG (cm)</th>
<th>HS (cm)</th>
<th>Tail (cm)</th>
<th>BW (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>♂</td>
<td>Nb</td>
<td>24.0</td>
<td>16.0</td>
<td>19</td>
<td>11</td>
<td>5.3</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>♀</td>
<td>Nb</td>
<td>25.5</td>
<td>16.0</td>
<td>18</td>
<td>12</td>
<td>6.7</td>
<td>0.48</td>
</tr>
<tr>
<td>3</td>
<td>♂</td>
<td>1</td>
<td>48.0</td>
<td>33.0</td>
<td>35</td>
<td>23</td>
<td>10.0</td>
<td>3.50</td>
</tr>
<tr>
<td>4</td>
<td>♀</td>
<td>1</td>
<td>51.0</td>
<td>51.0</td>
<td>40</td>
<td>25</td>
<td>9.5</td>
<td>4.50</td>
</tr>
<tr>
<td>5</td>
<td>♂</td>
<td>2</td>
<td>58.0</td>
<td>42.0</td>
<td>45</td>
<td>26</td>
<td>12.0</td>
<td>6.70</td>
</tr>
<tr>
<td>6</td>
<td>♀</td>
<td>2</td>
<td>51.0</td>
<td>36.0</td>
<td>40</td>
<td>28</td>
<td>13.0</td>
<td>10.50</td>
</tr>
<tr>
<td>7</td>
<td>♂</td>
<td>3</td>
<td>71.0</td>
<td>46.0</td>
<td>60</td>
<td>32</td>
<td>10.0</td>
<td>8.10</td>
</tr>
<tr>
<td>8</td>
<td>♀</td>
<td>3</td>
<td>81.0</td>
<td>52.0</td>
<td>73</td>
<td>36</td>
<td>13.0</td>
<td>20.00</td>
</tr>
<tr>
<td>9</td>
<td>♂</td>
<td>4</td>
<td>63.0</td>
<td>47.0</td>
<td>53</td>
<td>29</td>
<td>11.0</td>
<td>10.10</td>
</tr>
<tr>
<td>10</td>
<td>♀</td>
<td>4</td>
<td>90.0</td>
<td>60.0</td>
<td>78</td>
<td>44</td>
<td>21.0</td>
<td>24.40</td>
</tr>
<tr>
<td>11</td>
<td>♂</td>
<td>5*</td>
<td>77.0</td>
<td>59.0</td>
<td>59</td>
<td>34</td>
<td>13.0</td>
<td>15.60</td>
</tr>
<tr>
<td>12</td>
<td>♀</td>
<td>5*</td>
<td>91.0</td>
<td>64.0</td>
<td>77</td>
<td>41</td>
<td>20.0</td>
<td>30.00</td>
</tr>
</tbody>
</table>


upper labial, supra-orbital, zygomatic, buccal, mental and carpal regions. The most common mammary formula (i.e., the number of mammae in the thoracic, abdominal and inguinal regions) of CMP was 2+2+1=10 (66.6%). Other mammary formulae were 2+3+1=12 (16.7%) and 3+1+1=12 (16.7%) respectively. Zhang et al. (1986) noted that the mammary papillae of CMP are in 5 (93.2%) or 6 (6.8%) pairs. Carpal glands of CMP were present on the caudomedial side of the carpus and opened by five (4.2%), six (66.6%) or seven (29.2%) visible openings. They have been called “seven-stars” in China. Dyce et al. (1987) stated that the so-called carpal glands in the pig open by three or four small but visible orifices.

1. In 5-month-old CMP, the CL of the skin of the snout were transverse in the narrow area between the right and left nostrils, and on the lateral aspects of both sides of the snout, but were longitudinally arranged in its dorso- and ventro-medial aspects, and oblique in its dorso- and ventro-lateral areas. Behind the snout, the CL of the skin of the dorsal and lateral nasal regions were transversely arranged (Figs. 3 and 5), and in the skin of the buccal region they were consistently longitudinal (Figs. 5–10). In newborn CMP, both male and female, and in 3-month-old animals (again, both male and female) and in a 5-month-old female specimen, longitudinal lines were observed in the median part of the frontal region. However, in a 5-month-old male pig the CL were transverse on the dorsal aspect of the frontal region (Fig. 3).

As illustrated in Figs. 3 and 5, a typical radiating pattern was found at the medial angle of the eye, with an annular arrangement in the remaining skin around the eye. An annular arrangement was also seen at the base of the ear, with a more-or-less radiating pattern on both the dorsal and the ventral surfaces of the pinna. At 5 months of age, the CL of the skin in the median part of the mental region were longitudinal, while those in the caudal half of the intermandibular region (Figs. 3, 11 and 12) and in the masticatory region (Figs. 5–10) were transverse.

The CL of the skin of the neck of CMP were also transverse (Figs. 4–12). This is consistent with observations in the cat (Gardner & Raybuck, 1951), goat (Wakuri, 1961a), rabbit (Wakuri, 1961b), dog (Irwin, 1966), bovine and equine fetuses (Wakuri et al., 1986, 1987), horse (Wakuri et al., 1990), sheep (Wakuri et al., 1992, 1994) and pig (Wakuri & co-workers, 1967, 1993). In 5-month-old CMP, the CL of the skin of the dorso-lateral aspect of the trunk were usually also transverse. However, longitudinal lines were seen on the lateral surface of the trunk, running parallel to its long axis (see later). Striking longitudinal lines were also observed in the midline area of the sacral region. The CL were predominantly longitudinal in the ventral thorax in both male and female specimens (Figs. 4 and 11). However, in female newborn CMP, the CL in the ventral thorax were transverse (Fig. 12). As illustrated in Figs. 6–12, the CL were transverse on the lateral and ventral aspects of the abdominal region. The CL converged in the umbilical region and in the skin around the preputial orifice of CMP, but were longitudinally arranged in the remainder of the preputial skin. The CL of the skin of the mammae blended with those of the adjoining areas. Sometimes, the CL of the skin around the mammary papillae of CMP produced a circular pattern, as has been observed in the pig and the sheep (Wakuri et al., 1993, 1994). The CL formed a ring-shaped pattern along the whole length of the tails of the CMP.

The CL of the skin of the scapular region blended with those of the adjoining areas, being oblique over the
cranial half of the scapula, and longitudinal pattern over its caudal half and over the region of the triceps muscle. Irregular lines were noted in the skin over the triceps cartilage. A transverse pattern of CL appeared in the brachial, antebrachial and metacarpal regions, and in the skin of the digits of these forelimbs (Fig. 5).

The CL were transversely arranged on the dorsal surface of the pelvic girdle of CMP. In the ventromedian cleft ventral to the pelvic symphysis, the CL were longitudinal in males and transverse in females (Figs. 17 and 22). The scrotum of CMP was subanal, as described by Dyce et al. (1987), and its CL were oblique or transverse in its upper half and oblique direction on its lower half, with the CL over the upper half of the scrotal raphe being longitudinally arranged (Fig. 17). The CL of the vulvae of the CMP formed an annular pattern (Figs. 18-22). In both sexes, the CL of the skin surrounding the anus of CMP presented a convergent arrangement, but in the perineum they were sometimes transverse. The CL formed a longitudinal pattern over the laterocranial half of the thigh, an oblique pattern over the laterocaudal half of the thigh, and a transverse arrangement in the crur and in the skin of the digits of the hindlimb.

In summary, in 5-month-old CMP, the CL were transversely arranged on the dorsal side of the nose, over the masticatory and frontal regions, around the base of the ear, and on the neck, trunk, tail and the dorsal aspects of the fore and hind limbs. Longitudinal CL were found in the buccal and ventral thoracic regions, over the triceps brachii muscle, in the sacral region, on the latero-cranial half of the thigh, and, in males, ventral to the pelvic symphysis. These CL patterns were largely similar to those already described in adult Landrace-strain pigs (Wakuri et al., 1993).

2. In the CMP, at each of the 1–5 monthly periods examined, the CL of the skin of the interocular area of young specimens, at the medial canthus of the eye, and at the umbilicus, preputial orifice and anus presented a convergent arrangement (Figs. 5–22). At the newborn stage, a convergent pattern was seen only in the interocular part of the frontal region of a single female specimen. A convergent arrangement has been observed at the medial angle of the eye in adult pigs (Wakuri et al., 1993). However, in both young and adult pigs, the CL of the skin around the preputial orifice presented an annular pattern (Wakuri and co-workers, 1967, 1993), as in the goat (Wakuri, 1961a), bovine and equine fetuses (Wakuri et al., 1986, 1987), horses (Wakuri et al., 1990) and neonatal sheep (Wakuri et al., 1992). The CL of the skin around the umbilicus and anus consistently presented a convergent pattern in rabbits, young pigs, a young goat, and bovine and equine fetuses (Wakuri and co-workers, 1961a, 1961b, 1967, 1986, 1987). However, the CL of the skin around the umbilicus have shown an annular pattern in sheep (Wakuri et al., 1992, 1994).

3. Some alterations of CL were seen to accompany general and regional growth in the CMP. First, in newborn and one-month-old piglets, the CL pattern from the costal arch to the cranial part of the thigh region (i.e., lateral side of the abdomen, = flank) was moderately longitudinal in both male and female specimens. In 2-month-old animals of both sexes and in the one 3-month-old female, the CL pattern was predominantly longitudinal between the costal arch and the thigh region. However, in one 3-month-old male and at the 4-month-old stage in both male and female specimens, the CL pattern from the costal region to the thigh region was becoming transverse. Then at 5 months, these CL had become completely transverse. Secondly, the CL pattern in skin of the prepuce was at first transverse (in newborn, and at 1 month and 2 month stages), then longitudinal (at 3 months), again transverse (at 4 months) and finally longitudinal (at 5 months). Thirdly, in the scrotum, the CL of it were clearly longitudinal in the newborn and at the one month stage. At 2 months, the CL were oblique or transverse in the upper half of the scrotum. At the 3–4 months stages prominent longitudinal CL appeared again on the scrotum, and at 5 months the oblique-or-transverse pattern was re-appearing in the upper half of the scrotum (Figs. 11, 13–17). Fourthly, in the period from birth to 4 months of age, the CL in the skin of the digits of the forelimb were successively longitudinal, transverse, oblique, and then longitudinal again, and by 5 months they became predominantly transverse (Figs. 5–10). In the digital skin of the hindlimb the CL were oblique or transverse from birth to 3 months of age, oblique At 4 months of age and then transverse at the 5 months stage.

The twelve CMP used in the present study have revealed some developmental alterations in CL patterns as the body-proportions changed with the growth of the pigs. The recurrence of CL patterns reflected postnatal alterations typical of general and regional development, as shown in the skin of the lateral aspect of the abdomen and of the prepuce and the scrotum in CMP.

Developmental alterations in CL patterns have already been described in the skin of the equine fetus (Wakuri and Mutoh, 1987), juvenile and adult horses (Wakuri et al., 1990), young and adult pigs (Wakuri and co-workers, 1976, 1993) and the ovine fetus and neonatal sheep (Wakuri et al., 1992, 1994). Generally, the CL patterns altered during overall, regional and local growth. The occurrence of longitudinal patterns coincided with periods in which the respective regions or parts increased in length, and the appearance of oblique or transverse lines coincided with thickenings of underlying structures (Wakuri and Kirk, 1994). The alterations in the CL of the skin of the CMP thus reflected the changes in body-proportions which occurred during the
development and differentiation to the adult form.

Acknowledgement

This work was supported by a special research grant (1995) of the School of Veterinary Medicine and Animal Sciences, Kitasato University.

References

Explaination of Figures

Plate I

Fig. 1. Dorsal view of Cleavage Line patterns of the skin in a 5-month-old male CMP. Cleavage Lines are mainly transverse on the neck and the trunk. Longitudinal Lines can be seen in the dorsal midline part of the sacral region.
Plate II

Fig. 2. Sketch of a 3-month-old male pig, showing the body proportions, and the vibrissae and other primary hairs.

Fig. 3. Cleavage Line patterns of the skin of the nasal and frontal regions in a 5-month-old male pig. Dorsal view.

Fig. 4. Cleavage Line patterns of the skin of the intermandibular, cervical and ventral thoracic regions in a 5-month-old female pig. Ventral view.

Plate III

Fig. 5. Cleavage Line patterns of the skin in a 5-month-old male pig. Left view. Cleavage Lines are mainly transverse on the neck and on the lateral aspect of the trunk. Irregularly-oriented Lines can be seen in the scapular cartilage area.

Fig. 6. Cleavage Line patterns of the skin in a 4-month-old male pig. Left view. Cleavage Lines are mainly transverse on the neck and on the lateral aspect of the trunk. Transverse Lines can be seen in the scapular region.

Fig. 7. Cleavage Line patterns of the skin in a 3-month-old female pig. Left view. Cleavage Lines are mainly transverse on the neck and on the lateral aspect of the trunk. Transverse Lines can also be seen in the dorsal half of the femoral region.
Plate IV

Fig. 8. Cleavage Line patterns of the skin in a 2-month-old female pig. Left view. Cleavage Lines are mainly transverse on the neck and on the lateral aspect of the trunk. Note the conspicuous longitudinal Lines from the scapular to the femoral regions.

Fig. 9. Cleavage Line patterns of the skin in a one-month-old male pig. Left view. Cleavage Lines are mainly transverse on the neck and the lateral aspect of the trunk. Note, however, the oblique Lines on the lateral surface of the abdomen, and the longitudinal Lines caudally in the upper half of the femoral region.

Fig. 10. Cleavage Line patterns of the skin in a newborn male pig. Left view. Cleavage Lines are mainly transverse on the neck and on the lateral aspect of the trunk. Longitudinal Lines can be seen in the dorsal part of the flank. A longitudinal pattern (with respect to the limb) is present in the skin of the caudal half of the brachium, and a longitudinal-or-oblique pattern is seen in the digital skin in both the forelimb and the hindlimb.
Plate V

Fig. 11. Cleavage Line patterns of the skin in a newborn male pig. Ventral view. Cleavage Lines are mainly transverse, but a longitudinal pattern is seen on the ventral thorax and on the scrotum. Other Lines converge around the umbilicus, the preputial orifice and the anus.

Fig. 12. Cleavage Line patterns of the skin in a newborn female pig. Ventral view. Again, the Cleavage Lines are mainly transverse, with a convergent pattern in the skin around the umbilicus, the vulva and the anus. The Cleavage Lines are longitudinal in the ventral midline area between the inguinal region and the vulva.
Plate VI

Fig. 13. Cleavage Line patterns of the skin of the scrotum and anus in a one-month-old pig. Ventrocaudal view. Longitudinal Lines are seen in the skin of the scrotum. Around the anus the Cleavage Lines are convergent.

Fig. 14. Cleavage Line patterns of the skin of the scrotum and anus in a 2-month-old pig. Ventrocaudal view. The Cleavage Lines are longitudinal on the cranial half of the scrotum, and oblique or transverse on its caudal half. Transverse Lines are seen in the perineum.

Fig. 15. Cleavage Line patterns of the skin of the scrotum and anus in a 3-month-old pig. Ventrocaudal view. The Cleavage Lines are now all longitudinal on the scrotum.

Fig. 16. Cleavage Line patterns of the skin of the scrotum and anus in a 4-month-old pig. Ventrocaudal view. The Lines of the scrotum remain longitudinal, and in the perineum, they remain transverse.

Fig. 17. Cleavage Line patterns of the skin of the scrotum and anus in a 5-month-old pig. Ventrocaudal view. The Cleavage Lines on the cranial half of the scrotum are now largely oblique, but transverse in the midline area. On the caudal half of the scrotum the Cleavage Lines are largely oblique or transverse, but remain longitudinal in the midline area. In the perineum the Lines remain transverse.

Figs. 18–22. Cleavage Line patterns of the pigskin of the vulva and anus in a one-month-old (18), a 2-month-old (19), a 3-month-old (20), a 4-month-old (21) and a 5-month-old (22). Ventrocaudal view. In the vulva, the Cleavage Lines always formed an annular pattern. A convergent pattern is seen in the skin of the anus.