大韓獸醫學會誌(2008) 第48卷 第2號
Korean J Vet Res(2008) 48(2) : 235~238

Thoracic radiographic features in normal premature minipigs

Joohyun Jung, Jinhwa Chang, Sunkyoung Oh, Mincheol Choi*

College of Veterinary Medicine, Seoul National University, Seoul 151-742, Korea
(Accepted: April 30, 2008)

Abstract : This study describes thoracic radiographic features of normal premature minipigs at the age of 4, 8, 12 and 20 weeks. The evaluation for appearance, shape, contour, location and extent of distribution of thoracic organs was recorded through right lateral and ventrodorsal thoracic radiographs. The size of the tracheal diameter, cranial mediastinum, and the heart were measured, and information about the correlation of each organ in their thoracic conformation could be obtained. Although there were limitations with plain thoracic radiographs, basic characteristics and data for thoracic radiographs of normal premature minipigs according to each age were useful.

Keywords : premature minipigs, thoracic radiography

Introduction

Minipigs are considered the optimal transplant animals because pig's organs have similar size, anatomy and physiology to human organs [6]. Also, several factors such as rapid growth, short reproduction cycles, large litters, and relatively low costs for maintenance of hygiene standards can make pigs suitable as donor animals [6]. Therefore, the survey and selection of the normal healthy minipigs is important to several experiments for transplant. Radiographic standards for selection of healthy young minipigs are limited, and there is no widely studied basic data on thoracic radiographs in normal premature minipigs. Survey radiographic examination is a basic diagnostic imaging modality to identify the general anatomy of internal organs and assess the physical and pathological changes of the main organs and their adjacent structures [8]. Although plain thoracic radiographs do not provide precise measurements for function of thoracic organs and yield limited information, they can be used for general examinations of thoracic structures, especially correlation of organs. Therefore thoracic radiography remains a simple but essential tool to confirm and rule out thoracic diseases and has been widely used in various animals. The aim of this study is to assess the parameters for appearance, size, shape, contour, location and extent of distribution of thoracic organs in premature minipigs at the ages of 4, 8, 12 and 20 weeks. And these data were compared with those of conventional pigs, dogs and cats because minipigs's thoracic conformation is similar with those animals and veterinarians play a central role in the evaluation and selection of normal healthy minipigs.

Materials and Methods

Thoracic radiographs were obtained on healthy premature minipigs (PWG micro-pig minipig; PWG Genetics, Korea) at 4, 8, 12 and 20 weeks of age. No gender discrimination was used in the selection of minipigs. The number of examined minipigs in each age group was as follows: 9 at 4 weeks, 12 at 8 weeks, 9 at 12 weeks and 5 at 20 weeks. Before taking radiographs, all minipigs were fasted for 24 hours to reduce the abdominal pressure from ingesta and feces in their gastrointestinal tracts. Water was supplied *ad libitum*. Physical examinations and blood tests were performed prior to this study and only normal minipigs were included in this experiment.

Right lateral and ventrodorsal thoracic radiographs were taken at peak inspiration. The evaluations for appearance, shape, contour, location and extent of distribution of thoracic organs were recorded and

*Corresponding author: Mincheol Choi
College of Veterinary Medicine, Seoul National University, Seoul 151-742, Korea
[Tel: +82-2-880-1278, Fax: +82-2-880-8662, E-mail: mcchoi@snu.ac.kr]

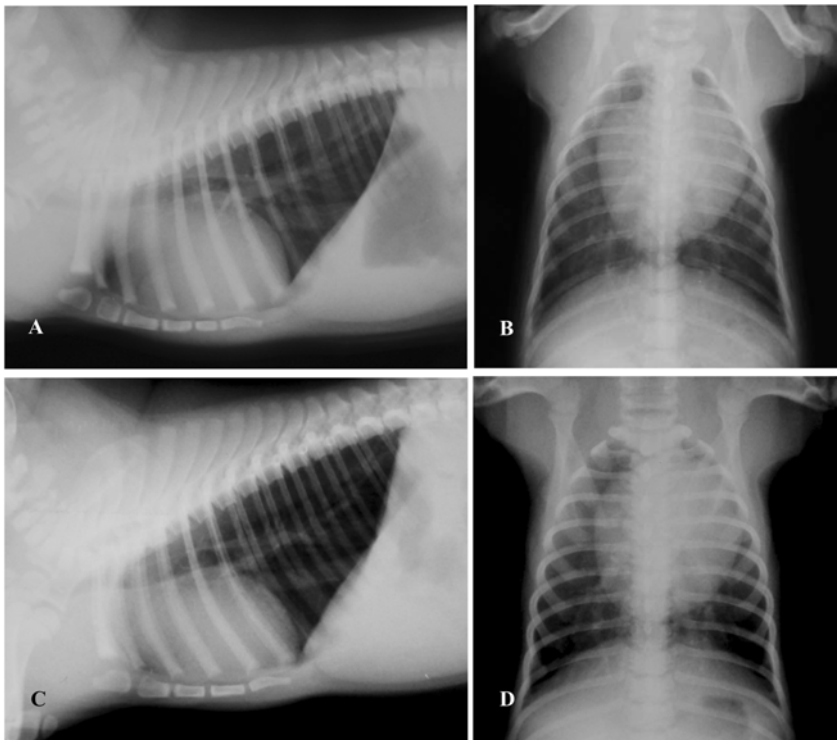

Fig. 1. Plain thoracic radiographs of premature minipigs (A and B: a 4-week-old minipig; C and D: an 8-week-old minipig) on the right lateral and ventrodorsal views. There are 5 (A) or 6 (B) sternums. The heart is located cranioventrally in the entire thoracic cavity.

compared with dogs and cats. The lengths and widths of several thoracic organs were measured using tape on the right lateral and ventrodorsal view films. To determine the range of normal cardiac size, the vertebral heart score (VHS) measurements [3] and cardio-thoracic ratios [4, 10] were used. All data were expressed in centimeters and recorded by the mean and standard deviation values (mean ± SD), respectively.

Results

Thoracic imagings of the normal premature minipigs are seen in Fig. 1. The thorax of minipigs was relatively small compared with their outer shape and weight. All minipigs had 14 pairs of rib and 14 thoracic vertebrae. Most minipigs had five sternums, however, nine out of 35 minipigs had six sternums.

The widths of the minipigs' cranial mediastinums were 2.17 ± 0.23, 2.26 ± 0.43, 2.23 ± 0.26 and 2.50 ± 0.16 (mean ± SD) cm at 4, 8, 12 and 20 weeks of age, respectively. The ratios between the width of the cranial mediastinum and the width of thoracic vertebrae at the same level were 1.99 ± 0.14, 1.95 ± 0.31, 1.78 ± 0.20 and 1.63 ± 0.17 (mean ± SD) cm at 4, 8, 12 and 20 weeks of age, respectively (Table 1).

The diameters of the thoracic inlet were 3.12 ± 0.19, 3.85 ± 0.42, 4.72 ± 0.56 and 4.94 ± 0.15 (mean ± SD) cm at 4, 8, 12 and 20 weeks of age, respectively. The diameters of the trachea in thoracic inlet region were 0.36 ± 0.04, 0.52 ± 0.14, 0.52 ± 0.12 and 0.56 ± 0.05 cm at 4, 8, 12 and 20 weeks of age, respectively. The diameter ratios of thoracic inlet and trachea were 0.12 ± 0.01, 0.13 ± 0.02, 0.11 ± 0.23 and 0.11 ± 0.01 cm at 4, 8, 12 and 20 weeks of age, respectively (Table 1). The minipigs' tracheobronchial bifurcations were located from the fifth rib to the seventh rib.

Normal measurements of the minipigs' heart size were recorded in Table 1. Their hearts were located in the craniaoventral thoracic cavity and within the intercostal space from the second rib to the seventh rib, showing some individual differences. The greatest widths of the cardiac silhouettes on the ventrodorsal

Table 1. Normal baseline data of thoracic radiographs in the premature minipigs

	4 weeks (n = 9)	8 weeks (n = 12)	12 weeks (n = 9)	20 weeks (n = 5)
The ratio of tracheal diameter to thoracic inlet diameter on lateral view	0.12 ± 0.01	0.13 ± 0.02	0.11 ± 0.23	0.11 ± 0.01
The ratio of cranial mediastinal width to vertebral body width on lateral view	1.99 ± 0.14	1.95 ± 0.31	1.78 ± 0.20	1.63 ± 0.17
Cardio-thoracic ratio on ventrodorsal view	75%	68%	66%	69%
VHS* on lateral view	9.22 ± 0.78	8.33 ± 0.46	7.96 ± 0.34	8.62 ± 0.28

*VHS: vertebral heart score.

view were at the fourth rib or intercostal space from the fourth to fifth ribs. Cardio-thoracic ratios were 75%, 68%, 66% and 69% at 4, 8, 12 and 20 weeks of age, respectively. VHSs were 9.22 ± 0.78, 8.33 ± 0.46, 7.96 ± 0.34 and 8.62 ± 0.28 cm at 4, 8, 12 and 20 weeks of age, respectively.

Discussion

The entire thoracic cavity of the minipigs was relatively small compared with their outer shape and weight, similar with thoracic conformation of conventional pigs [2]. All minipigs had 14 pairs of rib. Most conventional pigs have 14 or 15 pairs of ribs and thoracic vertebrae within the 13th to 17th rib range [2]. The number of sternums was five in most minipigs, however, nine out of 35 minipigs had six sternums. This difference seems that the manubrium of the sternum, first sternum, can be separated to two.

The widths of the minipigs' cranial mediastinum were 2.17 ± 0.23, 2.26 ± 0.43, 2.23 ± 0.26 and 2.50 ± 0.16 (mean ± SD) cm at 4, 8, 12 and 20 weeks of age, respectively. The ratios of the width of the cranial mediastinum and the width of thoracic vertebra at the same level were 1.99 ± 0.14, 1.95 ± 0.31, 1.78 ± 0.20 and 1.63 ± 0.17 (mean ± SD) cm at 4, 8, 12 and 20 weeks of age, respectively. There was no data for cranial mediastinum on conventional pigs. In dogs and cats, the normal width of the mediastinum on ventrodorsal or dorsoventral views is usually less than approximately twice the width of the vertebrae at the same level [9]. In obese dogs, the cranial mediastinum may be widened by fat accumulation and confused with a mediastinal mass [9]. The widths of cranial mediastinum in all premature minipigs were less than twice the width of the vertebrae in spite of fat. In small animals, the thymus lies in the cranioventral mediastinal reflection, and it can be identified on ventrodorsal or dorsoventral radiographs of young animals [9]. However, in premature minipigs, the thymus was not identified in either the lateral view or the ventrodorsal view. In conventional pigs, the thymus is well-developed and has the largest size at six months of age [1]. Further study is needed for evaluation of the thymus in thoracic radiographs of minipigs.

The trachea in premature minipigs was normally found slightly to the right in the cranial mediastinum like dogs and cats. The diameter of the overall trachea was relatively uniform and the diameters of the larynx and cervical trachea were slightly larger than that of the overall trachea. The diameters of trachea in thoracic inlet region were 0.36 ± 0.04, 0.52 ± 0.14, 0.52 ± 0.12 and 0.56 ± 0.05 cm at the age of 4, 8, 12 and 20 weeks, respectively. Also, the diameter ratios of trachea to thoracic inlet were 0.12 ± 0.01, 0.13 ± 0.02, 0.11 ± 0.23 and 0.11 ± 0.01 cm at the age of 4, 8, 12 and 20 weeks, respectively. In dogs, the mean ratio of the tracheal diameter to thoracic inlet diameter is 0.20 ± 0.03 in nonbrachycephalic breeds; 0.16 ± 0.03 in non-Bulldog brachycephalic breeds; and 0.13 ± 0.38 in Bulldogs [5]. Premature minipigs showed a small diameter of trachea, less than or similar to results of the tracheal diameter in Bulldogs.

The minipigs' heart was cranioventrally located in the thoracic cavity, and the location was demonstrated within intercostal space from the second rib to the seventh rib, showing some individual differences. The cardio-thoracic ratios were 75%, 68%, 66% and 69% at 4, 8, 12 and 20 weeks of age, respectively. VHSs were 9.22 ± 0.78, 8.33 ± 0.46, 7.96 ± 0.34 and 8.62 ± 0.28 cm at 4, 8, 12 and 20 weeks of age, respectively. In clinically normal dogs, the normal vertebral heart scale is 9.7 ± 0.5 vertebrae with the range of 8.7 to 10.7 [3]. One study demonstrated that the vertebral heart

score was 9.05 ± 0.15 in conventional pigs at 80 days old and 8.6 ± 0.14 in micropigs at 360 days old [7]. Definitely, Cardiomegaly was consistently present in all premature minipigs 4 weeks of age. Excluding 4 week old minipigs, most premature minipigs show a smaller heart size than dogs and conventional pigs. However, on the ventrodorsal view, the cardio-thoracic ratio of premature minipigs showed similar results with dogs. This seemed to be due to the relatively smaller thoracic cavity and cranially located cardiac silhouette in premature minipigs.

Radiography can not provide direct information about the internal structures and function of each organ. However, in this study, thoracic radiograph could provide valuable screening information about each organ according to each age. These results can be useful as standard criteria in the further studies of the evaluation and selection of normal minipigs.

Acknowledgments

This work was supported by a grant (2007 0401034006) from BioGreen 21 Program, Rural Development Administration, Korea.

References

1. 김무강, 김종섭, 김창기, 류시윤, 백영기, 신태균, 양홍현, 윤여성, 이성준, 이인세,이홍식, 임정택, 장병준. 돼지의 머리와 목. In: 수의해부학. p. 841, 정문각, 서울, 1994.
2. 김무강, 김종섭, 김창기, 류시윤, 백영기, 신태균, 양홍현, 윤여성, 이성준, 이인세,이홍식, 임정택, 장병준. 돼지의 척추, 등 및 흉곽. In: 수의해부학. pp. 845-849, 정문각, 서울, 1994.
3. **Buchanan JW, Bücheler J.** Vertebral scale system to measure canine heart size in radiographs. J Am Vet Med Assoc 1995, **206**, 194-199.
4. **Hamlin RL.** Analysis of the cardiac silhouette in dorsoventral radiographs from dogs with heart disease. J Am Vet Med Assoc 1968, **153**, 1446-1460.
5. **Kneller SK.** Larynx, pharynx, and trachea. In: Thrall DE (ed.). Textbook of Veterinary Diagnostic Radiology. 5th ed. pp. 489-494, Saunders, Philadelphia, 2007.
6. **Kues WA, Niemann H.** The contribution of farm animals to human health. Trends Biotechnol 2004, **22**, 286-294.
7. **Lee MY, Lee SH, Lee SG, Park SH, Lee CY, Kim KH, Hwang SH, Lim SY, Ahn YK, Han HJ.** Comparative analysis of heart functions in micropigs and conventional pigs using echocardiography and radiography. J Vet Sci 2007, **8**, 7-14.
8. **Suter PF.** Thoracic radiography: a text atlas of thoracic diseases of the dog and cat. pp. 324-331, Suter, Wettswil, 1984.
9. **Thrall DE.** The mediastinum. In: Textbook of veterinary diagnostic radiology. 5th ed. pp. 541-551, Saunders, Philadelphia, 2007.
10. **Toombs JP, Ogburn PN.** Evaluating canine cardiovascular silhouettes: radiographic methods and normal radiographic anatomy. Compend Contin Educ Pract Vet 1985, **7**, 579-587.