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Radiograph of Lung Lobation of the Sunda Porcupine (*Hystrix javanica*)

(RADIOGRAFI LOBUS PARU-PARU LANDAK JAWA (HYSTRIX JAVANICA))

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ABSTRACT

Sunda porcupine (*Hystrix javanica*) is one of the endemic porcupine species in Indonesia. The importance of wild species preservation brings with it the requirement for more basic aspects of anatomy. The knowledge of the normal radiological anatomy of the lung is of crucial importance for the making of a correct diagnosis of lung diseases. This study aimed to provide information about the radiographic anatomy in the lung lobation of sunda porcupine. This study was an explorative study using four sunda porcupines. Thoracic radiograph was retrieved using conventional and digital X-ray machine. Standard projections for thoracic radiography used lateral and ventrodorsal projection. The evaluation result of thorax radiogram showed that interlobar fissures separate the different lobes. The porcupine right lungs consist of four lobes, i.e. cranial lobe (cranial and caudal segment), middle lobe, caudal lobe, and accessory lobe, while left lung consisted of only two lobes, i.e. cranial lobe (cranial and caudal segment) and caudal lobe.

Keywords: fissure; lobe; lung; Sunda porcupine

ABSTRAK

Landak jawa (*Hystrix javanica*) merupakan salah satu spesies landak endemik Indonesia. Kebutuhan untuk pelestarian satwa liar membutuhkan pemahaman dasar dari aspek anatomi. Pengetahuan anatomi radiografi normal pada paru-paru sangat penting dalam menegakkan diagnosis dari penyakit paru-paru. Penelitian ini bertujuan memberikan informasi tentang anatomi radiografi lobus paru-paru landak jawa. Penelitian ini bersifat eksploratif menggunakan empat ekor landak jawa. Radiografi toraks diperoleh menggunakan mesin sinar-x konvensional dan radiografi digital. Proyeksi standar yang digunakan pada pengambilan radiografi yaitu proyeksi lateral dan ventrodorsal. Hasil evaluasi radiogram menunjukkan adanya fissura yang memisahkan lobus yang berbeda. Paru-paru kanan landak jawa terdiri atas empat lobus, antara lain lobus kranialis (pars kranialis dan pars kaudalis), lobus tengah, lobus kaudalis, dan lobus aksesori, sedangkan paru-paru kiri terdiri atas dua lobus, yaitu lobus kranialis (pars kranialis dan pars kaudalis) dan lobus kaudalis.

Kata-kata kunci: fissure; lobus; paru-paru; landak jawa

INTRODUCTION

Sunda porcupine (*Hystrix javanica*) is one of the porcupine endemic species in Indonesia which can be found in Java, Bali, Sumbawa, Flores, Lombok, Madura, and Tanah Jampea Island (Van Weers, 1979; Van Weers, 1983; Purwaningsih, 2013). The need for wild species preservation brings with it the requirement for more basic aspects of anatomy, physiology, pathophysiology, and clinical knowledge of these animals to applied questions focused on conservation or management of entire population or species, providing valuable data for zoological medicine (Alves *et al*., 2012; Buccholtz *et al*., 2007; Fox *et al*., 2008; Osofsky *et al*., 2001; Paul *et al*., 2016).

Radiography is an essential step in the diagnosis of most thoracic diseases (Brinkman *et al.*, 2006). Lung lobe radiograph is common in small animal practice but less common in wild animal, especially Sunda porcupine. Knowledge of gross and radiographic anatomy of the porcupine lung is essential to the discussion of diagnostic radiography and the interpretation of porcupine thoracic radiographs. The knowledge of the normal radiological anatomy of the lung is of importance for the making of a correct diagnosis of lung diseases in the clinical practice (Spasov *et al.,* 2018). The aim of the present research is to provide information about the normal anatomy radiographic in of the lung lobation of Sunda porcupine.

RESEARCH METHODS

Ethical Approval

Ethical approval had been obtained from Animal Ethics Committee of Institute for Research and Public Service Program of IPB University with the approval number, 130-2018 IPB, and permission from the Directorate General of Forest Protection and Nature Conservation under the Ministry of Environment and Forestry of the Republic of Indonesia with the number, 386/KSDAE/SET/KSA.2/10/2017. The radiographic examinations were carried out as per the standard procedure without harming the animals.

Animals

Four healthy Sunda porcupines (3 males and 1 female) were used. During the acclimatization period, the samples were fed with vegetables, fruits, and drinking water in *ad libitum*. All porcupine presented for general health check up to the My Vets Animal Clinic, Bumi Serpong Damai (BSD) in South Tangerang and IPB Veterinary Teaching Hospital were subjected to thorough physical examination. Only those considered healthy and free from any cardiovascular disease underwent a radiographic examination of the thorax.

Sedation Protocol

The animals were sedation with xylazine (Xyla® Interchemie, Holland) at 2 mg/kg, intramuscularly in the dorsal part of the animal's tail (Morin and Berteaux, 2003). The blood pressure, heart, and respiratory rate were monitored throughout the procedure.

Radiographic Examination

All foreign bodies are removed in the radiographic examination – leash, neckpiece, bandages, dirt, water, blood. The patient must be immobilized to the limit. For fixation various accessories are used – bags with sand, a rope, adhesive materials, and straps – minimum radiological load of the assistants. Thoracic limbs must be stretched ahead.

The radiographic examination included lateral and ventrodorsal (VD) projections. Radiography was performed with sedation using standard exposure techniques. All radiographs were taken at the time of full inspiration using digital x-ray machine (Indoray IKL-17E-100/24) and x-ray flat panel detector (CareView 1800L - 17x17" Tethered, CareRay Medical Systems Co.). Radiographs should be made during the inspiratory pause because when the lungs are filled with air, maximal contrast is achieved between the different structures within the thorax (Kealy *et al*., 2010). The apparatus was calibrated with 1 m focus film-distance and exposure techniques of 50 kVp and 6 mAs.

An attempt was made to keep the chest of animal as close to the flat panel detector as possible, to include all the thoracic vertebrae in radiographs and to avoid any rotation of the body of animal. To obtain a ventrodorsal view, the animal is placed in dorsal recumbency with the forelimbs drawn forward and the beam centered over the caudal edge of the scapula. The ventrodorsal should be straight with the sternum lined up with the thoracic vertebrae and the rib heads should be overlapping on the laterals. For a lateral view the sternum should be lifted for the sternum and the spine to be at

an equal distance from the film (Spasov *et al.,* 2018). The x-ray beam was centered over the heart. All diagnostic imaging studies were evaluated using MicroDicom DICOM viewer. Data were analized using descriptive analysis only or no statistical method.

RESULTS AND DISCUSSION

A Sunda porcupine is a completely different species in regard to radiographic anatomy. Radiograph of lung lobe of Sunda porcupine on ventrodorsal projection was presented in Figure 1. A radiograph of the lung field is a composite shadow of many structures, including the pulmonary vasculature, bronchi, bronchioles, alveolar ducts, alveoli, interstitial tissue, lymphatics, pleurae, and thoracic wall. Because the arteries and veins lie alongside the bronchi, the bronchial walls contribute to the vascular outlines seen (Kealy *et al*., 2010).

The lungs are the largest organs in the lower respiratory tract. The lung field is easily distinguished from other organs because it contains air which produces a black image (radiolucent). Air attenuates very little of the x-ray beam, allowing nearly the full force of the beam to blacken the image (Brant and Helms, 2006). The lungs appear translucent with only branches of the pulmonary arteries and veins visible (Patel, 2007). The hilus is that part of the lung at which the bronchi, pulmonary vessels, bronchial vessels, and nerves enter (Kealy *et al*., 2010). The first consideration when evaluating radiographs for pulmonary disease is whether the lungs are normal. In general, this is determined by the opacity of the lungs (Nykamp *et al*., 2002). Normal is not synonymous to non-structural. Normal means without radiographic signs of pathology (Spasov *et al*., 2018).

The lungs are located in the thorax cavity on either side of the heart in the rib cage. The lungs of Sunda porcupine is semi-conical in shape, with an oblique surface and apex, base, lateral surface (costal), medial surface (mediastinum), caudal surface- diaphragmatic), dorsal border, ventral border and basal border that are similar to other-mammal. The apex lung lies above the first rib. Interlobar fissures separate the different lobes (Kealy *et al*., 2010).

While the two lungs are similar, they are not completely symmetrical, having a different number of lobes and a different bronchial and

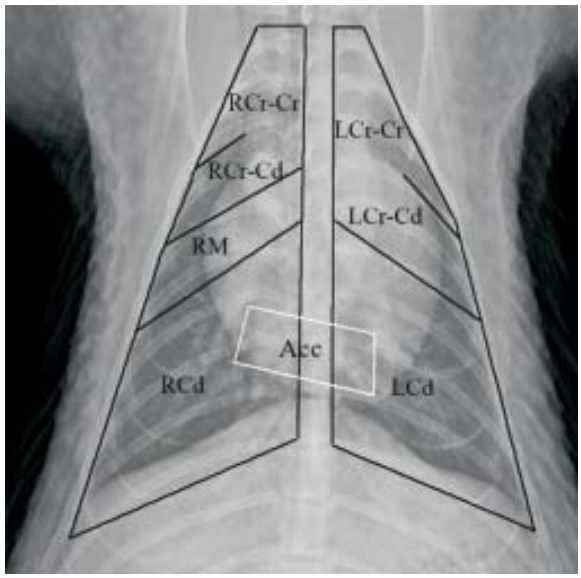

Figure 1. Ventrodorsal sunda porcupine thoracic radiograph where the approximate location of lung lobes is indicated. *Acc:* Accessory lobe, *LCd:* left caudal lobe, *LCr-Cd:* caudal segment of left cranial lobe, *LCr-Cr:* cranial segment of left cranial lobe, *RCd:* right caudal lobe, *RCr-Cd:* caudal segment of right cranial lobe, *RCr-Cr:* cranial segment of right cranial lobe; *RM,* right middle lobe.

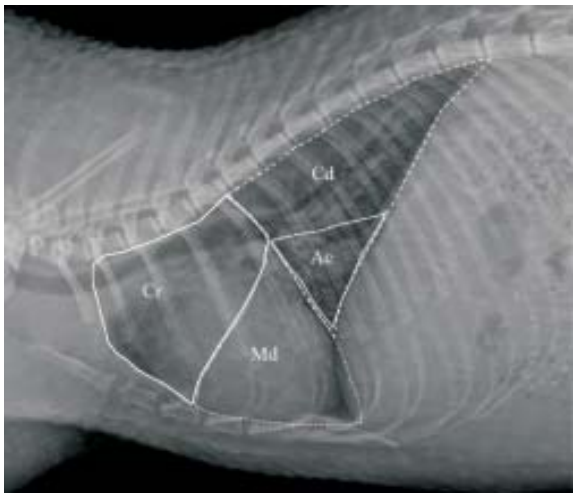

Figure 2 Lateral sunda porcupine thoracic radiograph where the approximate location of lung lobes is indicated. Ac*:* Accessory lobe, *Cd:* right and left caudal lobes, *Cr:* right cranial lobe and cranial segment of left cranial lobe, *Md:* right middle lobe and caudal segment of left cranial lobe.

vascular anatomy. The left lung has two lobes, a cranial and a caudal. The cranial lobe is divided into cranial and caudal segments. The left lung has small size when compared with right lung due to the presence of heart near left lung which is characterized by a deep heart curve at the anterior border of the left lung (Ramchandani *et al*., 2001; Aung *et al*., 2019). The right lung has both more lobes and segments than the left. The right lung is divided anatomically by fissures into four lobes lobes i.e. cranial (apical), middle (cardiac), caudal (diaphragmatic) and accessory lobes (intermediate or azygos). Only the right lung have a middle lobe. The cranial lobe of the right lung, like the left, is divided into cranial and caudal. This result coincide with most researches studies on most domestic animals have four lobes (Ozdemir *et al*., 2006; Santos *et al*., 2011; Guimaräes *et al*., 2012; Jabbar and Al Ammer, 2014).

The right cranial lobe extends from the lung apex to the oblique fissure border and middle lobe. Middle lobe is located between right cranial lobe and right caudal lobe which is bordered by the oblique fissure. The left cranial lobe is larger than the right cranial lobe, extending from the lung apex to the oblique fissure border, and directly adjacent to the caudal lobe. The right and left caudal lobe is the largest lobe of the the lung, located at the bottom, and directly in contact with the diaphragm.

On inspiration, the left cranial lobe extends beyond the first pair of ribs and projects a little into the right side of the thorax at its cranial extremity. At full inspiration, the right middle lobe may extend underneath the heart, between it and the sternum, particularly in the left lateral recumbency. This should not be mistaken for pneumothorax. Dorsally, the lungs extend on either side of the vertebral column to the level of the costovertebral junctions (Kealy *et al*., 2010).

On normal radiographs, the fissure between the right and left cranial lobes is usually seen

Table 1. Lobation of lungs the domestics, wild animals, and mammals.

Species	Lobation		Reference
	Right Lung	Left Lung	
Sunda porcupine (*H. javanica*)	Cra (cranial and caudal segment), med, cau, acc.	Cra (cranial and caudal segment), cau.	This study
Crested porcupine (*H. cristata*)	Cra (cranial and caudal segment), med, cau, acc.	Cra (cranial and caudal segment), cau.	Ozdemir *et al*., 2006.
Hairy dwarf porcupine (*Sphiggurus villosus*)	Cra (cranial and caudal portion), med, cau, acc.	Cra (cranial and caudal portion), cau.	Guimaräes *et al*., 2012.
Local hedgehogs (subfamily Erinaceinae)	Cra, med, cau, acc	Left lobe	Kazemi-Darabadi *et al*., 2018; Yakubu *et al*., 2018
Rat (*Rattus norvegicus*)	Cra, med, cau, acc.	Left lobe	Júnior *et al*., 2005; Navarro *et al*., 2017.
Guinea pig (*Cavia porcellus*)	Cra, med, cau, acc	Cra (cranial and caudal segment), med, cau.	Stan, 2015.
Rabbit (*Oryctolagus cuniculus*)	Cra, med, cau, acc.	Cra, med, cau.	Stan, 2015.
Dogs, cats, and suines	Cra, med, cau, acc.	Cra (cranial and caudal segment), cau.	Dyce *et al*., 2010; Noviana *et al*., 2018
Jaguarundi (*Herpailurus yagouaroundi*)	Cra (cranial and caudal segment), med, cau, acc.	Cra (cranial and caudal segment), cau.	Santos *et al*., 2011
Common marmoset (*Callithrix jacchus*)	Cra, med, cau, acc.	Cra dan cau.	Falcão *et al*., 2018
Fox (*Cerdocyon thous*)	Cra, med, cau, acc.	Cra (cranial and caudal segment), cau.	Dantas *et al*., 2014.
Crab-eating raccoon (*Procyon cancrivorus*)	Cra, med, cau (cranial and caudal segment), acc.	Cra, cau.	Sestari *et al*., 2011

Cra: *Lobus cranialis*, Med: *Lobus medius*, Cau: *Lobus caudalis*, Acc: *Lobus accessorius*.

on the lateral view. The fissure is seen as a faint linear opacity, cranial to the heart, extending from approximately the second or third sternebra cranially and dorsally to blend with the ventral border of the cranial mediastinum at the level of the first rib. There is a considerable overlapping of lung lobes in the lateral, ventrodorsal, and dorsoventral views (Kealy *et al.*, 2010).

Sunda porcupine has identical lobation with four lobes of the right lung (the cranial, middle, caudal, and accessory lobes) and two lobes of the left lung (the cranial and caudal lobes). The right and left cranial lobe is characterized by two distinct segments, the cranial and caudal segments (Figure 1). The location of the lung lobes in Figure 2 is approximate because there is considerable overlap of individual lobes in three-dimensional space, and accurate depiction of their exact location in a two-dimensional image is not possible. The right cranial lobe had extended from the 1st to the 6th rib. The middle lobe is located in the 6th to the 8th rib, and the right caudal lobe is located in the 8th to 12th rib . The whole accessory lobe had laid in the dorsal part of the heart and inclined toward the left and its ventral part had extended to the tip of the heart. The left cranial lobe had extended from the 1st to the 8th rib, and the right caudal lobe is located in the 8th to 12th rib (Figure 1).

Regarding the fissures, the cranial interlobar fissure was identified in the right lung, that separated the cranial and middle lobes; the caudal interlobar fissures that divided the caudal lobe of the cranial and middle lobes and the parasagittal fissure separating the caudal and accessory lobes. In the left lung, cranial and caudal lobes were separated by oblique fissure, also cranial lobe divided by incomplete fissure to cranial and caudal parts.

The results of the study showed that the area of the lung of the Sunda porcupine in each lobe was different. This is because the lungs have different interlobular surfaces in each lobe (Navarro *et al.*, 2017). The right lung grows faster than the left so that it is larger and has more bronchial branches (Berrocal *et al.*, 2004). The caudal lobe is larger than the cranial lobe because they are conical in shape with a narrow rounded apex at the top, and a broad concave base that rests on the convex surface of the diaphragm. (George *et al.*, 2005; Navarro *et al.*, 2017; Urden *et al.*, 2017).

Lobation of the lung varies greatly among species (Harkema *et al.*, 2013). Lobation of lungs the domestics, wild animals, and mammals were presented in Table 1. The anatomy and physiology that make this happen varies greatly, depending on the size of the organism, the environment in which it lives and its evolutionary history (Price *et al.*, 2018). The interlobus segment serves to localize disease in the lungs and prevent the spread of infection, so that if one of the lobes is damaged, infected, or its function is disrupted, the other lobe can still function normally (Marini 2010). The pulmonary lobation is also similar to that of the crested porcupine (*H. cristata*) and the hairy dwarf porcupine (*Sphiggurus villosus*), the right lung has cranial lobe (cranial part and caudal part), middle lobe, caudal lobe and accessory lobe, while the left lung consists of the cranial lobe (cranial part and caudal part) and caudal lobe. However, each lung lobe has the same function, which is to picks up oxygen for cellular use and drops off carbon dioxide (Tortora dan Derrickson 2009; McLafferty *et al.*, 2011).

CONCLUSION

The present study demonstrates that the Sunda porcupine right lungs consist of four lobes, i.e. lobes cranial (apical), middle (cardiac), caudal (diaphragmatic) and accessory lobes (intermediate or azygos). Left lung consisted of only two lobes, i.e. cranial and caudal lobe. The cranial lobe of the right and lung are divided into cranial and caudal. Interlobar fissures separate the different lobes.

SUGGESTION

Further research is needed by using other supporting tools.

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