UNIVERSITY OF VETERINARY MEDICINE, BUDAPEST

DEPARTMENT OF SURGERY AND OPHTHALMOLOGY

CT ASSESSMENT OF PRESSURE-DEPENDENT LUMINAL VARIATION IN FELINE LOWER AIRWAYS

CASE STUDY

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Abstract

This study investigated bronchial luminal dimensions in eleven healthy feline subjects during controlled mechanical ventilation at two distinct intra-airway pressure settings: end-expiratory pressure (0 cmH_2O) and 15 cmH_2O. Measurements were obtained at seven predetermined anatomical locations within the lower airways.

Significant variation in airway luminal diameter was observed between the two pressure conditions. During the end-expiratory phase, mean luminal diameter measurements ranged from 1.1 to 4.3 mm across the different bronchial locations, yielding an overall mean of 2.4 mm. At peak inspiration with an intra-airway pressure of 15 cmH_2O, the mean luminal diameter increased to 3.5 mm.

Broncho-arterial (BA) ratio of a single patient studied demonstrated notable pressure-dependent changes. At baseline end-expiratory conditions, BA ratios in two orthogonal measurement planes were 0.61 and 0.65. Following the application of positive intra-airway pressure at 15 cmH_2O, both values increased substantially, with BA ratios reaching 1.14. and 1.36 respectively.

The present investigation establishes morphometric data for feline bronchial dimensions under controlled pressure conditions and provides comparative analysis with existing literature, contributing to the establishment of reference values for future clinical and research applications.

Absztrakt

Ez a tanulmány tizenegy egészséges macska hörgőátmérő méreteit vizsgálta kontrollált gépi lélegeztetés során két különböző légúti nyomásértéken: végkilégzési nyomáson (0 cmH_2O) és 15 cmH_2O-n. A méréseket az alsó légutak hét előre meghatározott anatómiai pontján végeztük el.

Jelentős eltérést figyeltünk meg az átmérőkben a két nyomáskörülmény között. A kilégzési fázisban az átlagos átmérők 1,1 és 4,3 mm között változtak a különböző pontokon, amely összességében 2,4 mm átlagot eredményezett. A belégzés csúcsán, 15 cmH_2O légúti nyomás mellett, az átlagos átmérő 3,5 mmre növekedett.

Egy macskában a broncho-arteriális (BA) arányt is vizsgáltuk, mely kifejezett, nyomásfüggő változásokat mutatott. Alapállapotban, kilégzésvégi mérési körülmények mellett a BA arány két egymásra merőleges síkban 0,61 és 0,65 értéket adott. A 15 cmH_2O pozitív légúti nyomás alkalmazását követően mindkét mérési irányban számottevő emelkedés volt megfigyelhető, a BA arányok 1,14-re, illetve 1,36-ra nőttek.

Jelen vizsgálat morfometriai adatokat állapított meg macskák hörgőméreteiről kontrollált nyomáskörülmények között és összehasonlító elemzést nyújt a meglévő szakirodalommal, hozzájárulva a referencia értékek meghatározásához jövőbeli klinikai és kutatási alkalmazások számára.

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1. Introduction

1.1. Background:

1.1.1. History and use of CT in airway assessment in human and veterinary medicine:

Computed tomography was first performed on a live human patient by Godfrey Hounsfield and radiologist James Ambrose on October 1, 1971. With this a new, revolutionary era has begun in medical imaging [1].
The introduction of multidetector row CT (MDCT) technology has transformed non-invasive diagnostic imaging. This transition offered improved resolution, quicker scan times, broader anatomical details and the capability to generate isotropic datasets with uniform resolution across different planes[2].
The use of CT for clinical purposes in veterinary medicine was first documented in the 1980s to investigate diseases of the central nervous system and neoplasia in canine patients [3].
Since then, computed tomography (CT) has become necessary to the diagnostic evaluation of different pathologies. Thoracic CT utilization in veterinary medicine has not yet achieved widespread use. This can be attributed to the delayed adoption of multidetector row CT technology, limited accessibility beyond academic institutions and large referral clinics. Limitation of use also include the obligatory use of general anaesthesia to reduce motion artifacts [4].

1.1.2. Normal airways and influence of intra-airway pressure

The lower airways consist of semi rigid structures supported by cartilaginous rings and smooth muscles that maintain airway patency. Airway caliber (diameter or cross sectional passage) is determined by transmural pressure which is the difference between the intraluminal (pressure inside the airway lumen) and extraluminal (peribronchial pressure surrounding the airway wall) pressures [5].
Airway wall compliance describes the expandability of these structures in response to pressure changes.
During inspiration, negative pleural pressure creates a transmural pressure gradient. This is causing intrathoracic airways to dilate, while during expiration positive pleural pressure

leads to airway narrowing. The degree of caliber change depends on both pressure and the luminal compliance [5].
This physiological variation in airway dimensions throughout the respiratory cycle creates challenges for obtaining standardized measurements. Controlled intra airway pressure decreases respiratory dependent fluctuations and enables accurate morphometric assessment under standardised conditions.

1.1.3. Anatomy and function of feline lower airways

The feline lower respiratory tract begins where the trachea enters the chest and continues through smaller airways until reaching the alveoli where the gas exchange occurs. The feline trachea consists of approximately 37-43 incomplete cartilage rings shaped like the letter “C”, with the open part of the rings connected by a smooth muscle[6].The trachea splits at the ridge called carina (located at the level of the fourth or fifth rib) into two main airways: the right and left principal bronchi [6]. An important anatomical difference is that the right principal bronchus continues almost straight from the trachea, while the left principal bronchus angles off more sharply[6]. The right lung has four lobes (cranial, middle, caudal, accessory), while the left lung has two lobes (cranial subdivided into two sublobes and caudal). Each lobe receives air through its own bronchus [6, 7]. The pulmonary arteries and veins run dorsolaterally and ventromedially accompanying the corresponding bronchial structure. Larger bronchi continue dividing into smaller and smaller branches called the segmental bronchi, then subsegmental bronchi, eventually forming the terminal bronchioles in cats [6, 7].
The microscopic structure of feline airways changes as they get smaller, which reflects their different functions. Large airways like the trachea and main bronchi have several distinct layers: the innermost surface is lined with ciliated columnar cells mixed with glands secreting mucous and the rigid cartilage provides structural support [8].
As the airways branch and become smaller, the amount of cartilage decreases, and smooth muscle becomes more dominant. These smaller airways are called bronchioles and have no cartilage or mucous glands at all [8].
Terminal bronchioles, which are the last airways before the gas exchange regions are lined with simple cuboidal cells and surrounded by thin layers of smooth muscle. These then transition to respiratory bronchioles, which have a few alveoli (air sacs) in their walls, before opening into the alveolar ducts and sacs where gas exchange takes place [8].

One of the most important features of feline airways is a high amount of smooth muscle compared to other animals of similar size. Studies examining normal cat lung tissue show prominent bands of smooth muscle around the bronchi and bronchioles and this smooth muscle becomes even thicker in cats with inflammatory airway diseases like asthma [8]. Additionally, cats have narrower airways compared with dogs of similar body weight, which makes them more vulnerable to breathing problems when airway walls thicken or mucous accumulates [7].

While both dogs and cats possess collateral ventilation pathways including pores of Kohn and canals of Lambert, cats may have less extensive collateral ventilation (air to flow between different parts of the lung) compared to dogs. This feature makes them more susceptible to atelectasis following bronchial obstruction [9].

This means that if a bronchus becomes blocked, the lung tissue beyond that blockage is more likely to collapse. These unique anatomical features together explain why cats are particularly susceptible to lower airway disease and why precise measurement of airway dimensions is important for both research and clinical diagnosis.

1.2. Problem statement

1.2.1. Lack of data on how airway lumina (bronchial lumen) change with varying pressure in cats

Cross sectional bronchial diameters provide an important measurement reference in the investigation of certain disease conditions, primarily bronchiectasis and bronchial collapse (bronchomalacia), chronic bronchitis and occasionally, pulmonary hypertension. These include the bronchial lumen diameter to pulmonary artery and the bronchial wall thickness to artery ratios. However, the lumen diameter shows variability with airway pressure values and respiratory phase.

This variability may be excessively high in an individual with pathological conditions such as bronchial collapse, and its physiological extent varies by species and is incompletely documented in cats. According to recent research results, for example, in healthy dogs, this value can reach up to 50% under mechanical ventilation [10].

Because of the above, it seems that other anatomical structures (thoracic vertebral body) may provide a more reliable basis for division. We aimed to assess how the lumen diameter of lobar and segmental bronchi varies with airway pressure in CT scans of clinically

healthy cats that were imaged for reasons unrelated to respiratory disease or airway abnormalities.

1.3. Rationale of the study

Characterizing normal pressure-dependent variation in airway dimensions is essential for identifying pathological airway morphology and compliance.
By establishing the relationship between controlled intra-airway pressure and luminal dimensions in healthy cats, this study could provide the certain data necessary for developing standardized CT protocols that minimize pressure-related measurement variability.

1.4. Objectives

Computed tomography has become an essential diagnostic tool in veterinary medicine for evaluating feline respiratory diseases, offering superior visualization of airway structures compared to conventional radiography[4]. High-resolution CT imaging allows for precise quantification of bronchial dimensions through standardized measurement ratios, including the bronchial lumen to pulmonary artery diameter ratio (BA ratio), bronchial lumen to vertebral body diameter ratio (BV ratio), and pulmonary artery to vertebral body diameter ratio (AV ratio) [11]. These measurements have proven valuable in detecting and monitoring various airway pathologies, including bronchiectasis, feline asthma, and chronic inflammatory airway disease.
The effect of intra-airway pressure on bronchial dimensions has been recognized as an important factor in CT imaging protocols. Studies in feline thoracic CT have consistently employed a standardized positive pressure breath-hold technique during image acquisition, typically maintaining an airway pressure of 15 cmH_2O to minimize motion artifacts and ensure reproducible measurements [7]. Understanding the pressure-dependent behaviour of airways is very important for accurate interpretation of CT measurements and for distinguishing physiological airway changes from pathological ones [7].
In both human and veterinary medicine, the relationship between lung volume, airway pressure and bronchial dimensions has been shown to significantly influence measurements gained from CT imaging. Recent studies have shown that variations in

inspiratory lung volume can affect bronchial diameter measurements and broncho-arterial ratios, potentially impacting the accuracy of disease detection and monitoring [12].
In human medicine, differences in lung volume greater than 10% between time points have been shown to significantly influence bronchial dimensions and BA metrics [12].
Additionally, the standardization of measurement techniques using vertebral body diameter as an anatomical reference has emerged as a valuable approach, particularly in situations where both bronchial and vascular structures may be affected by disease processes [11].

The general objective is to evaluate how controlled positive intra-airway pressure affects luminal size of feline lower airways using CT imaging.

The specific objectives are to quantify airway luminal dimensions at two distinct pressure levels (0 cmH_2O and 15 cmH_2O) using standardized measurement ratios. These measurements will be performed at lobar bronchial levels to assess pressure effects across different airway paths.

2. Literature review

2.1. Mechanics and airway resistance

The mechanical properties of the airways play a primary role in determining bronchial dimensions during computed tomography (CT) imaging, especially under controlled ventilation. Airways exhibit significant distensibility in response to positive pressure, with studies demonstrating that fully relaxed airways can reach maximal size at pressures near total lung capacity [13]. The application of positive pressure ventilation leads to increased bronchial diameters, with the extent of change being substantially greater in bronchial structures compared to adjacent pulmonary arteries [13]. This differential response reflects the greater compliance of airway walls compared to vascular structures. The inspiratory pressure required to overcome airway resistance and achieve proper lung inflation varies with the ventilation method. It was studied on multiple feline subjects to compare various ventilation protocols and observe that inadequate peak inspiratory pressures can lead to reduced diagnostic quality due to the development of atelectasis, while excessive pressures may induce barotrauma and adverse cardiovascular effects [14].

2.2. Bronchial lumen diameter variations

2.2.1. Bronchial lumen to pulmonary artery (BA) ratio

The bronchial lumen to pulmonary artery diameter ratio (BA ratio) has appeared as a basic measurement in veterinary thoracic CT imaging. In feline medicine, normal BA ratio values have been established through multiple studies although with certain variations depending on the methodology. It has been measured previously that the mean BA ratio is 0.86 in healthy cats using high-resolution computed tomography (HRCT), while other researchers documented a slightly lower value of 0.71 in anesthetized ventilated cats with normal lungs [15, 16]. These measurements were obtained using standardized protocols where cats were positioned in sternal recumbency under general anaesthesia with controlled positive-pressure ventilation. The precise measurements usually require adequate attention to anatomical location and image quality. It was described by measuring the internal diameter of the bronchial lumen and the diameter of the adjacent vessels with

measurements obtained from the cranial and caudal subsegments of the left cranial lung lobe, right middle lung lobe and left and right caudal lung lobes.
Significance of species difference was revealed in normal BA ratios. For example, in canine studies it was reported that a mean BA ratio is 1.45 in subjects without clinical pulmonary disease showing that this result is substantially higher than the feline values [17].
This variance may reflect inherent anatomical and physiological differences between species.

2.2.2. Effect of ventilation pressure on bronchial dimensions

Ventilation pressure significantly influences bronchial lumen dimensions in other species, a critical consideration for standardization of CT imaging protocols. The most commonly reported protocol involves maintaining airway pressure at 15 cm H_2O during image acquisition. Reid et al. (2012) described their technique: "A single-breath hold technique (airway pressure maintained at 14–15 cm of water) was utilized during thoracic CT image acquisition."[16]. Similarly, Cannon et al. (2009) stated that "examinations were performed with dogs in sternal recumbency under general inhalational anaesthesia using a single breath-hold technique with airway pressure maintained at 15 cm of water." [17].
Researchers compared bronchial and pulmonary artery diameters during positive-pressure inspiration with end expiration in dogs and found statistically significant differences. It was found that bronchoarterial ratios acquired using positive pressure inspiration were statistically greater than the results gained from end expiration [13]. It was further explained by researchers the pressure dependent changes in bronchial dimensions: "The application of positive pressure to the airway resulted in increased diameters of the bronchi and decreased diameters of the pulmonary arteries. Changes in the bronchi are in agreement with previous publications. It has been shown in a canine model that fully relaxed airways are quite distensible reaching a maximal size with no further distension up to total lung capacity at a pressure of 30 cm of water."[13].

2.2.3. Bronchial diameter and airway generation

The relationship between airway size and how much the airway can collapse also varies depending on the branching level. It was found in dogs that airways at different branching

levels showed different patterns of collapse with more distant airways (those that have branched many times) behaving differently than the larger airways closer to the trachea [18]. Other researchers demonstrated that there is a strong relationship between how wide a bronchus is and its BA ratio, larger airways consistently had higher BA ratios than smaller airways. When they divided airways into large and small groups based on their diameter, they found that large bronchi had an average BA ratio of about 1.39 compared to only 1.08 for small bronchi and this difference was statistically significant [13].
This size dependent and branching level dependent variation has important practical implications for veterinary clinicians. Normal reference values obtained from large airways near the trachea cannot be directly applied to small airways deep in the lung without taking into account their different sizes and branching levels [13].

2.3. Bronchial wall thickness variations

2.3.1. Normal bronchial wall thickness in cats

Bronchial wall thickness in healthy cats has been quantified using standardized ratios that account for individual anatomical variation. Won et al. in healthy cats examined under positive pressure inspiration, studies have measured bronchial wall thickness using two primary ratios: the ratio of bronchial wall thickness to bronchial diameter (TD ratio) and the ratio of bronchial wall thickness to adjacent pulmonary artery diameter (TA ratio). Normal cats show a TD ratio of approximately 0.18 and a TA ratio of approximately 0.25, meaning the bronchial wall is roughly 18% of the total bronchial diameter and 25% of the adjacent artery diameter [15]. The bronchial lumen to pulmonary artery ratio (BA ratio) in healthy cats averages around 0.86, indicating that the bronchial lumen is slightly smaller than the accompanying pulmonary artery. Similar measurements have been established in dogs, where the mean BA ratio is approximately 1.45, indicating species specific differences in airway to vessel relationships [17]. These measurements are obtained by calculating wall thickness as the difference between the outer bronchial diameter and inner lumen diameter divided by two [15]. Studies using HRCT with thin-section imaging (1-1.25 mm slice thickness) have demonstrated that these measurements are highly reproducible and can be reliably obtained across different lung lobes in anesthetized, ventilated animals [16].

2.3.2. Effects of airway pressure on wall thickness

Airway pressure has a significant effect on bronchial dimensions and the apparent thickness of bronchial walls during CT imaging. The relationship between pressure and wall thickness is complex, involving both passive distension and changes in wall tension. Studies in dogs have demonstrated that bronchial diameter changes significantly during different phases of respiration with bronchi showing minimal collapse at end inspiration but distinct narrowing during expiration. During forced expiration, bronchial collapsibility can range from approximately 17% to 62% depending on the lung lobe with the left cranial and left caudal lobes typically showing greater collapse than right-sided bronchi [18]. In healthy dogs examined at different respiratory phases, bronchial collapsibility measured during end expiration averaged around 4-21% but increased to 10-55% during forced expiration at 10 ml/kg and 17-61% at 15 ml/kg forced expiration [18]. These changes in luminal diameter directly affect the calculation of wall thickness ratios, as the wall thickness (calculated as outer diameter minus inner diameter divided by two) appears proportionally larger when the lumen narrows during expiration. Studies comparing inspiration and expiration CT images have shown that bronchial collapsibility exceeding 50% can occur in healthy animals during forced expiration, particularly in the dorsal and ventral segments of the left cranial lobe and the left caudal lobe [10]. The application of positive pressure inspiration (typically 14-20 cm H_2O) standardizes bronchial dimensions by maximally dilating the airways, thereby providing consistent conditions for measuring true wall thickness rather than pressure dependent luminal changes [16, 18]. This standardization is critical because measurements obtained during different respiratory phases or pressure conditions cannot be directly compared and reference values established at one pressure may not apply to images acquired under different ventilation conditions.

2.3.3. Vertebral body diameter as reference standard

Evaluating bronchial dimensions using the bronchial lumen to pulmonary artery (BA) ratio presents challenges in certain clinical situations. When pathological processes simultaneously affect both the airways and pulmonary vasculature the reliability of this ratio significantly decreases. Conditions such as feline lungworm infections can alter both bronchial and arterial measurements compromising the diagnostic utility of their ratio [11]. The same limitation applies when patients present with concurrent conditions, for example when bronchial dilation occurs alongside elevated pulmonary arterial pressure [11]. Recognizing these limitations, it was proposed using a stable intrathoracic structure as an alternative reference point. The sixth thoracic vertebral body offers a consistent anatomical landmark unaffected by cardiopulmonary disease processes. By comparing bronchial lumen diameter to vertebral body diameter (BV ratio) and pulmonary artery diameter to vertebral body diameter (AV ratio), clinicians can assess each structure independently, enabling more accurate evaluation in complex cases where traditional BA ratios would be unreliable [11].

The vertebral body based measurement system offers several distinct advantages over the traditional BA ratio measurements. Using the vertebral body-based ratios enables more precise evaluation of cats presenting with simultaneous bronchial and pulmonary arterial pathology. The predictable nature of vertebral dimensions established a standardized comparative denominator for calculating both BV and AV ratios. This measurement approach makes it particularly valuable in complex clinical cases [11].

2.4. Species differences in airway measurements

2.4.1. Feline vs. canine comparisons

Computed tomographic investigations have demonstrated significant differences in bronchial dimensions between cats and dogs, which demands the establishment of species-specific reference values for accurate clinical assessment. When comparing the bronchial lumen to pulmonary artery diameter (BA) ratio under standardized ventilation protocols cats and exhibits distinctly different baseline measurements. Feline studies using specific pathogen free (SPF) animals with confirmed lung function reported a mean BA ratio of

0.71, with values between 0.50 to 1.11 across individuals [16]. Based on these findings a value exceeding 0.91 may indicate abnormal airway dilation in cats [16].

In comparison to canine research substantially higher BA ratios were documented, with mean values reaching 1.45 and individual variances between 0.8 to 2.0 [17].These findings demonstrate that dogs naturally have proportionally larger airway lumina relative to their adjacent pulmonary vasculature when compared to cats.

Importantly, BA ratio measurements show consistency across different pulmonary lobes in both species, which suggests that the relationship between airway and vascular dimensions remains relatively uniform throughout the lung under normal conditions. Feline measurements across different lobar locations ranged from 0.68 to 0.79, with statistical analysis revealing no meaningful differences between anatomical sites [16]. Canine data similarly demonstrated uniform distribution with lobar values between 1.41 to 1.52 also showing no significant statistical variation [17].

Assessment of bronchial wall thickness reveals additional interspecies differences. When evaluating healthy feline airways, researchers documented a TD ratio (wall thickness relative to total bronchial diameter) of 0.18 [15]. Cats diagnosed with asthma based on clinical criteria showed distinctly increased values, with TD ratios reaching 0.22. The respiratory phase during image acquisition substantially affects canine bronchial measurements. Researchers have found comparing different ventilation states that BA ratios during positive pressure inspiration (1.24) exceeded those recorded at end expiration (1.11) [13].

Furthermore, airway size influences the measured ratio as larger bronchi demonstrated elevated BA values (1.39 at peak inspiration) compared to smaller peripheral airways (1.08), highlighting the importance to standardize measurement location within the bronchial structure [13].

2.4.2. Human medicine parallels

Examination of bronchial measurements across veterinary and human patients reveals similarities in measurement techniques along with variations in reference values that shape how diagnostic standards are defined for different species.

Human diagnostic standards define bronchial dilation when the BA ratio over 1.0, which is the primary criteria for identifying bronchiectasis [18]. This value differs from the canine upper threshold of 2.0, though it more closely resembles the feline limit of 0.91 [16, 17].

Human studies using computed tomography have characterized bronchial dimensions throughout the airway generations. Adult human data indicate that wall thickness reduces progressively from 1.4 mm at the tracheal level to 0.8 mm to 2.0mm [19]. Consecutive bronchial generations demonstrate a consistent proportional reduction with each following generation showing smaller lumen diameter (approx. 14%) and reduced wall thickness (approx. 4%) compared to its parent airway [19]. This systematic dimensional decrease enables prediction of normal airway measurements at specific generational levels.
Changes caused in the lumen of bronchial tree associated with respiration demonstrate comparable characteristics across the examined species. Research in healthy human subjects documented collapsibility between 57% and 64% during maximal expiratory effort, suggesting that the conventional 50% threshold for diagnosing bronchomalacia may require upward adjustment [20].
Canine research showed similar results with healthy dog showing median collapsibility of 17% to 46% across different lobar bronchi during forced expiration and certain individuals demonstrating values above 50% [18].
Healthy canine subjects demonstrated average bronchial collapsibility of 38%, though individual measurements above 50% were recorded in several dogs, predominantly affecting the left caudal lobe and the segmental divisions of the left cranial lobe [17].
Anatomical location influences the degree of bronchial collapsibility in a consistent manner across species. Human research established that airways located further from mediastinal structures exhibit greater collapsibility because peripheral lung tissue provides less mechanical support than central mediastinal tissues [20]. Canine findings support this observation, demonstrating that bronchi on the left side collapse more readily than those on the right, with maximum collapsibility occurring in the left cranial and caudal lobes during forced expiratory maneuvers [18].
Veterinary researchers have adapted the concept of using stable anatomical structures as reference standards, similar to approaches employed in human thoracic imaging. The establishment of bronchial lumen to vertebral body diameter (BV) ratios and pulmonary artery to vertebral body diameter (AV) ratios in cats provides a method for separately evaluating airway and vascular alterations when diseases affect both structures simultaneously [11]. This methodology offers particular advantage in cases where conditions such as bronchiectasis appears with pulmonary hypertension because the conventional BA ratio becomes unreliable when both measured structures differ from normal [11]. The vertebral body diameter remains stable in cats beyond seven months of

age, thereby providing a reliable normalizing parameter for longitudinal monitoring, comparable to the application of fixed reference landmarks in human diagnostic imaging [11].

2.5. CT imaging techniques for measuring airway morphology

Computed tomography is now considered the gold standard for assessing bronchial structure in both human and veterinary medicine showing strong agreement with histopathological findings [16]. Acquiring high-quality CT images depends on proper patient positioning, appropriate ventilation protocols and optimized scanning parameters. Superior image quality is achieved when animals are mechanically ventilated under anaesthesia with controlled breath holds during inspiration.[4] For feline imaging, cats are typically positioned in sternal recumbency and scanned during a controlled inspiratory pause to reduce motion artifacts [7].

Modern CT technology enables acquisition of thin slices that reduce volume averaging and images are processed with appropriate reconstruction algorithms and window settings to enhance visualization of airway structures [4].

Bronchial dimensions can be quantified on CT using either manual or automated methods. Manual techniques employ electronic calipers to measure bronchial lumen and pulmonary artery diameters with measurements taken at the narrowest point to avoid overestimation from oblique imaging angles [16]. Automated software can identify and segment the bronchial tree by creating perpendicular cross-sectional images that allow measurement of wall thickness, lumen diameter and vessel dimensions across multiple bronchial generations [19].

Measurements obtained during positive pressure inspiration differ from those at end expiration and larger airways yield higher broncho-arterial ratios than smaller airways [13]. Consequently, controlling inspiratory volume is critical for accurate airway assessment.

3. Materials and methods

This prospective observational cohort study was designed to systematically evaluate the effects of controlled intra-airway pressure on feline lower airway using computed tomography imaging. Study subjects were selected through precise screening to ensure optimal pulmonary health. Cats with signs of lower airway or pulmonary disease were excluded. Only cats meeting inclusion criteria were enrolled in the final study cohort.
In this study, feline patients of the Small Animal Clinic at the University of Veterinary Medicine Budapest who required thoracic computed tomography for reasons unrelated to the research were evaluated between 2023 and 2025.
From the selected patients, 7 were neutered female cats, 3 were intact female cats and one was a castrated male cat. The age varied between 11 to 16 years old for 8 cats considered being senior patients, however for 3 cats the age was between 1 to 7 years old considered being adults.

All CT examinations were performed using a 16-slice multi-detector computed tomography scanner (General Electric Revolution ACT). General anaesthesia was induced using midazolam (0.25mg/kg, Dormicum 5mg/ml, Egis) and propofol 1% (5mg/kg Fresenius) intravenously. After endotracheal intubation, isoflurane (2% V/V) was used with an anesthesia machine (Dräger Primus), which also allowed for control of ventilatory parameters. Continuous monitoring of airway pressures was achieved through the ventilator's integrated respiratory monitor unit. Each subject underwent scanning under two distinct ventilatory conditions: first at 0 cmH_2O end-expiratory pressure, then at 15 cmH_2O of positive airway pressure.
This dual-pressure protocol enabled direct comparison of airway dimensions under physiologically relevant conditions. For all imaging acquisitions, cats were positioned in sternal recumbency to maintain anatomical consistency and minimize gravitational effects on airway configuration.
Thoracic CT protocol was used in helical scanning mode with a slice thickness of 1.25 mm and lung algorithm. This was selected to provide optimal spatial resolution for visualization and measurement of small airway structures.

Image analysis was conducted using a commercially available DICOM viewer software (RadiAnt; version 2025.1). Luminal cross-sectional diameters were measured with electronic calipers on axial images.

Statistical analysis of the results was performed using R software, version 4.3.2 (2023-10-31 ucrt). Descriptive statistics (mean, standard deviation, median, minimum and maximum) were calculated for each lung lobe under end-expiratory (referred to as "deflated" from here on) and at 15cm H_2O (referred to as "inflated" from here on) conditions.

Graphical summaries were generated to visualize measurement distributions and compare values within subjects. Paired differences (inflated-deflated) were also computed to evaluate deviations and variability across cats and bronchi.

The help of AI (Claude.ai) was incorporated for exploring more peer-reviewed scientific articles and to ensure grammatical accuracy in Chapter 1.4.

4. Results

The results were obtained at seven different measurement points at the following anatomical structures:

- at both mainstem bronchi directly after the carina,

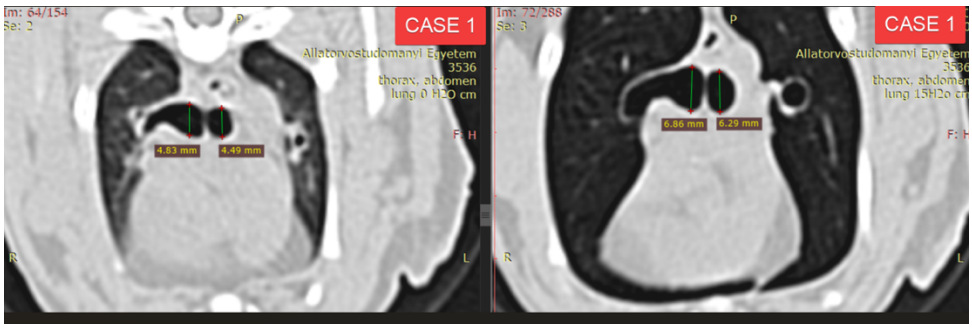


Figure 1. Measurement at the level of the main bronchi in Case1

- at the bronchi of both right and left caudal lobes directly after the branching out of the first dorsal segmental bronchi between the artery and vein, and the bronchus of the accessory lobe at the same segment

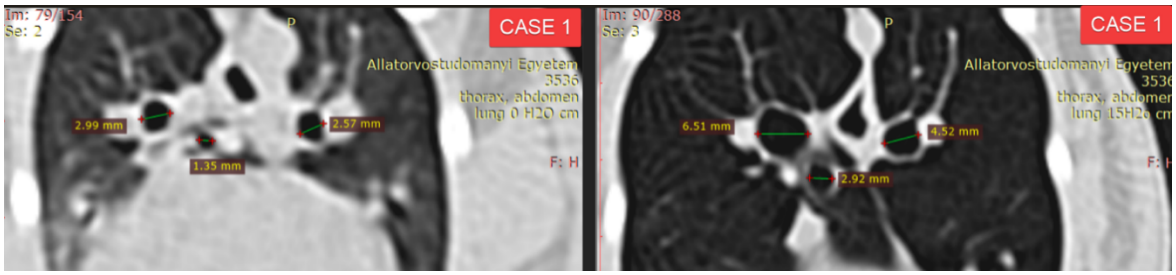


Figure 1. Measurement at the right and left caudal lobes and accessory lobe in Case1

- at the bronchi of the cranial lobes directly after the branching of the second ventral segmental bronchus

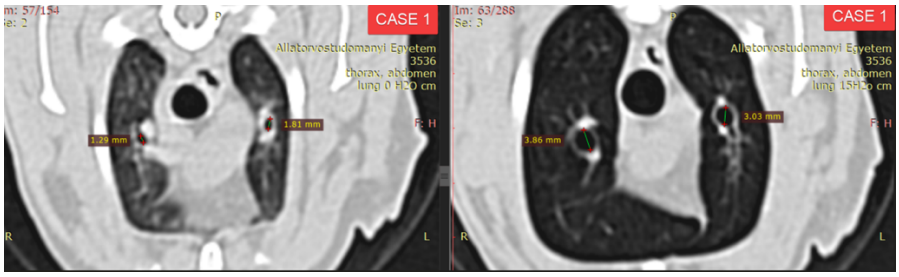


Figure 2. Measurements at the right and left cranial lobes in Case1

Individual assessment of maximal bronchial diameter was performed for each subject across both ventilatory conditions in this study, and a consistent pattern of luminal diameter enlargement was documented across the entire study cohort (Table 1).

Name	Sex	Age	Defl	(mm)						Inf	(mm)					
			RCR	LCR	RMB	LMB	RCA	LCA	ACC	RCR	LCR	RMB	LMB	RCA	LCA	ACC
Case 1	f/n	12	1.3	1.8	4.8	4.5	3.0	2.6	1.3	3.9	3.0	6.9	6.3	6.5	4.5	2.9
Case 2	f/n	11	1.4	0.9	4.9	4.8	2.8	2.5	1.3	1.5	1.5	5.2	4.9	3.7	2.8	1.5
Case 3	f/n	1	1.4	1.0	3.8	3.8	2.4	1.9	1.3	1.7	1.7	5.0	4.6	3.3	2.8	1.5
Case 4	f/n	12	1.4	1.5	4.4	4.1	2.5	2.1	1.4	2.5	3.0	4.8	4.8	3.5	3.1	2.7
Case 5	f	7	1.2	1.1	4.3	4.6	2.3	1.8	1.3	1.8	1.7	4.8	5.2	3.6	2.8	1.4
Case 6	f	15	1.6	1.6	4.1	3.9	2.9	2.4	1.1	1.8	2.5	4.7	4.0	3.0	2.8	1.2
Case 7	f/n	16	1.1	0.8	3.9	3.4	1.7	1.6	1.3	1.1	1.0	4.3	4.5	2.9	3.3	1.5
Case 8	f/n	14	1.0	0.7	3.9	3.2	1.8	2.0	1.0	1.9	1.9	6.6	6.0	4.5	4.6	1.9
Case 9	f	13	1.7	1.1	4.5	4.2	3.8	3.1	1.4	2.2	2.2	5.1	4.7	4.4	3.8	2.8
Case 10	m/n	11	1.2	0.7	3.7	3.0	2.2	1.4	1.0	1.7	2.1	5.5	4.3	3.7	2.7	2.1
Case 11	f/n	5	0.9	0.8	4.7	4.1	2.5	2.1	1.0	2.7	2.3	6.2	6.5	5.9	4.8	2.4

Table 1. Results of the bronchial lumen measurement

Table 2. summarizes the descriptive statistics for each lobe examined at the end expiratory ("deflated") and at 15 cmH_2O ("inflated") conditions, including mean, standard deviation, minimum, maximum and median.

	RCR	LCR	RMB	LMB	RCA	LCA	ACC	RCR_infl	LCR_infl	RMB_infl	LMB_infl	RCA_infl	LCA_infl	ACC_infl
Mean (mm)	1.3	1.1	4.3	4	2.5	2.1	1.2	2.1	2.1	5.4	5.1	4.1	3.5	2
Standard Deviation (mm)	0.2	0.4	0.4	0.6	0.6	0.5	0.2	0.8	0.6	0.8	0.8	1.2	0.8	0.6
Minimum (mm)	0.9	0.7	3.7	3	1.7	1.4	1	1.1	1	4.3	4	2.9	2.7	1.2
Maximum (mm)	1.7	1.8	4.9	4.8	3.8	3.1	1.4	3.9	3	6.9	6.5	6.5	4.8	2.9
Median (mm)	1.3	1	4.3	4.1	2.5	2.1	1.3	1.8	2.1	5.1	4.8	3.7	3.1	1.9

Table 2. Descriptive statistics of lobe measurements in deflated and inflated conditions.

In Figure 4. paired line illustrates within-subject changes between deflated and inflated states. Each line connects a pair of measurements for a single cat, allowing direct

visualization of individual-level differences. This representation highlights consistent increases in inflated measurements across most bronchi and cats.

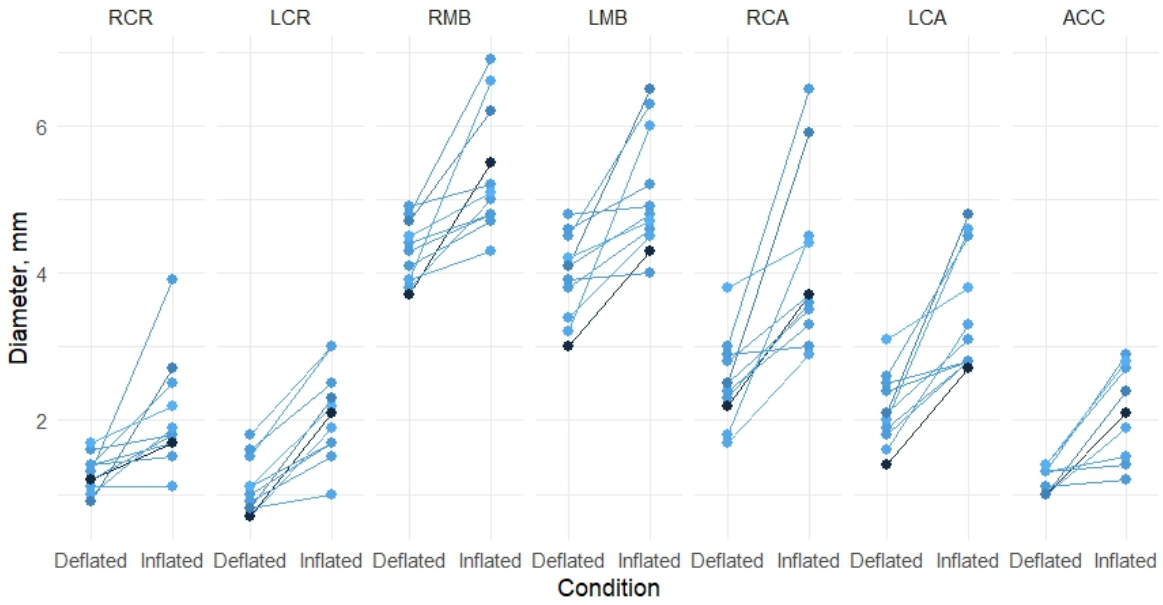


Figure 3. Paired lobe measurements for deflated and inflated conditions

Because paired differences directly quantify how much inflated measurements exceed deflated values, they offer insight into variation in healthy feline population. Table 3. summarizes the differences (inflated minus deflated) for each lobe.

Lobe	Mean (mm)	SD (mm)	Min (mm)	Median (mm)	Max (mm)
RCR	0.8	0.8	0	0.5	2.6
LCR	1.0	0.4	0.2	1.1	1.5
RMB	1.1	0.8	0.3	0.6	2.7
LMB	1.1	0.9	0.1	0.8	2.8
RCA	1.6	1.1	0.1	1.2	3.5
LCA	1.3	0.8	0.3	1.0	2.7
ACC	0.8	0.6	0.1	0.9	1.6

Table 3. Descriptive statistics of paired differences

Notably, the standard deviations (SD) of the differences are relatively large for most bronchi, indicating substantial variability between cats. This suggests that while the general trend shows positive airway pressure measurements exceeding end-expiratory ones, the magnitude of this difference varies considerably across individuals. Such

variability should be considered when establishing diagnostic thresholds or reference intervals.

Figure 5. shows the paired difference between positive airway pressure and end-expiratory measurements (inflated - deflated) for each lung lobe across all cats. Positive values indicate that inflated measurements were larger than deflated measurements.

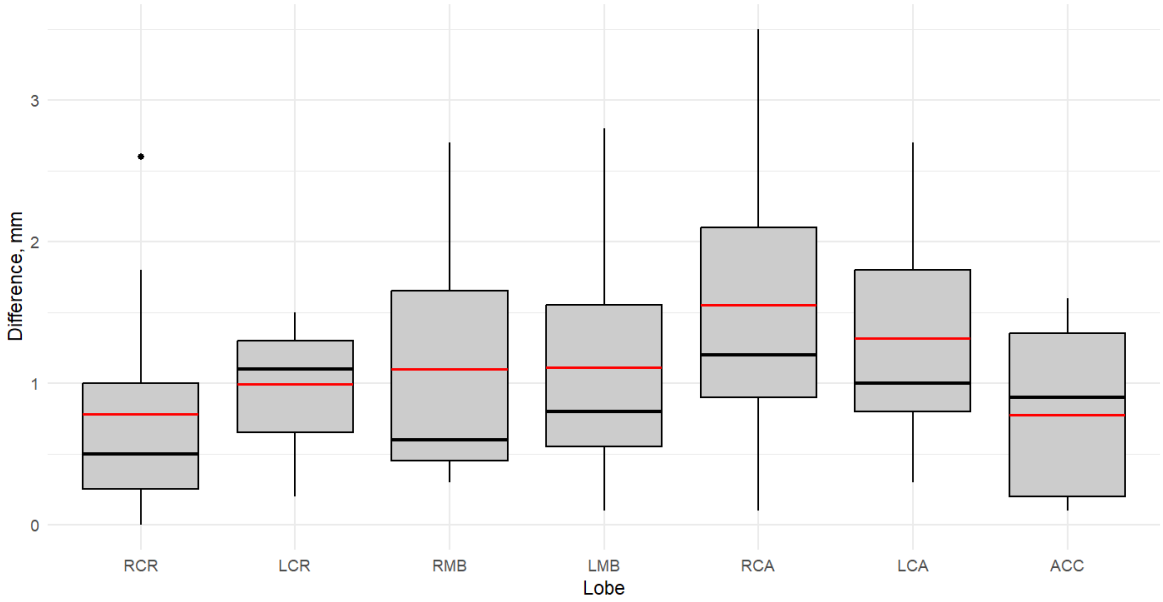


Figure 4. Boxplots showing paired differences (inflated - deflated) for each lung lobe (black: median; red: mean)

The present study demonstrated statistically significant alterations in bronchial luminal dimensions across all anatomical regions examined. This statement was also supported by a permutation test, where the corresponding p-value was < 0.001.

These morphometric changes were consistently observed at an intra airway pressure of 15 cmH_2O. While individual variations were noted, all specimens exhibited measurable increases in luminal diameter under the applied pressure conditions.

5. Discussion

The present study investigated morphometric changes in feline bronchial dimensions in response to controlled intra airway pressure variations. The findings demonstrate statistically significant alterations across all anatomical regions examined, with bronchial luminal measurements at 15 cmH_2O showing substantial increases compared to 0 cmH_2O. Universal reference values for normal bronchial diameters do not exist for either humans or animals. Nevertheless, the bronchial lumen can be evaluated by comparing it with the corresponding pulmonary artery and reporting the measurement as a bronchoarterial (BA) ratio.

The results of this research have important implications for understanding feline airway dynamics and the interpretation of broncho-arterial (BA) ratio measurements in clinical veterinary practice.

One of the most significant findings relates to how moderate alterations in bronchial luminal diameter can produce substantial variation in the BA ratio. The reason for this variation is the different response of bronchial and arterial structures to pressure changes across the seven anatomical points examined.

The specific intra-airway pressure at which BA ratio measurements are obtained is critical, for example at 15 cmH_2O, the results are significantly altered not only by the increased bronchial luminal diameter but also by the simultaneous reduction in arterial diameter compared to the measurements at 0 cmH_2O as is demonstrated in Figure 5.

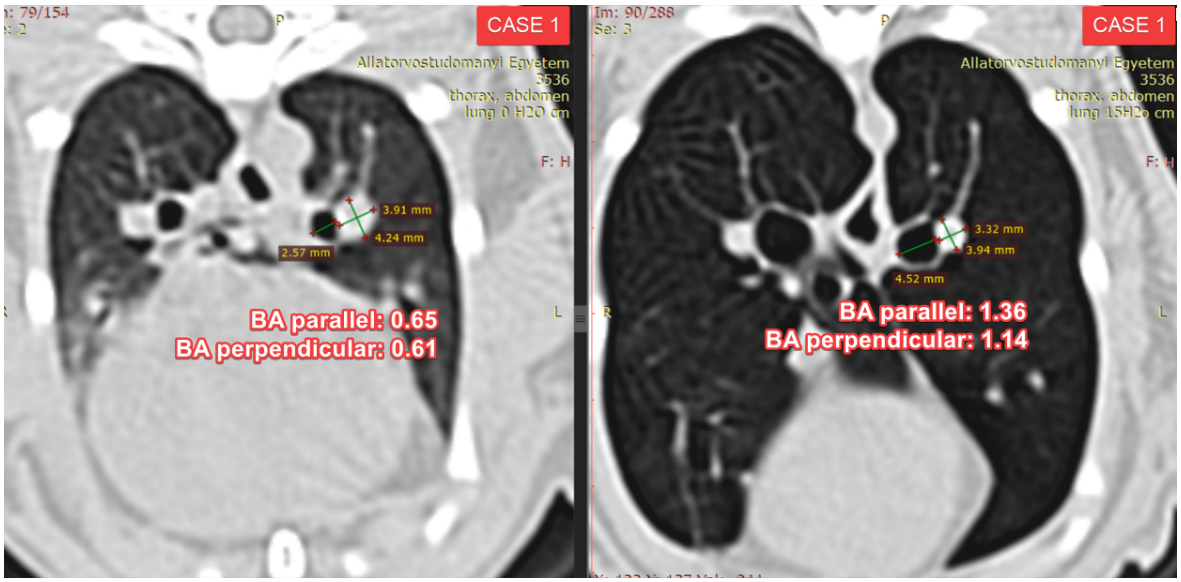


Figure 5. BA ratio variances measured at different intra airway pressures

In our research, in Case 1, the BA parallel ratio measured 0.65 and the BA perpendicular ratio measured 0.61 at baseline. When intra-airway pressure was increased to 15 cmH_2O, both ratios increased, with the BA parallel ratio reaching 1.36 and the BA perpendicular ratio reaching 1.14.
The end-expiratory BA ratio values obtained in this study were slightly lower than those reported in the literature for feline patients, where the value was 0.86 in healthy individuals at the same condition [15]. However, a separate feline-specific investigation in the available literature demonstrated a broader range of BA ratio values, with measurements spanning from 0.5 to 1.11 [16]. In this study, the mean broncho-arterial ratios across individually examined lung lobes showed no significant variation, with values falling between 0.68 and 0.79. When averaged across all lung lobes, the overall mean BA ratio was 0.71 [16].

When comparing the present findings to existing literature, the value obtained from Case 1 appears slightly below the baseline threshold established by Won et al. (2017), which could raise clinical concerns regarding potential bronchial collapse [15]. Conversely, when evaluated against the reference values reported by Reid et al. (2012), this measurement falls within the accepted physiological range for normal bronchial luminal patency [16]. However, for instance, in healthy dogs the BA ratios ranging from 0.8 to 2.0 have been reported, with a BA ratio exceeding 2.0 serving as the threshold value for distinguishing between normal and pathological bronchial structure [16].

Reid et al. proposed that a broncho-arterial ratio exceeding 0.91 serves as the threshold for distinguishing between healthy and diseased cats [16]. This research indicates that the normative upper limit for BA ratio in cats is lower compared to dogs, approximating the established maximum value of 1.0 observed in healthy humans [16]. However, additional investigation was recommended to establish whether a BA ratio exceeding 0.91 represents a reliable cutoff for distinguishing normal from pathological airways [16].

Research conducted by Makara et al. reported a BA ratio of 1.39 at peak inspiration, a value that exceeds our measurement at Case 1 (1.36) by only 0.03 [13]. This finding challenges the prevailing assumption in the literature that canine patients exhibit greater bronchial luminal elasticity compared to felines. The similarity between our results and

those obtained from canine studies suggests that the expected species difference in bronchial compliance may be less pronounced than previously documented.
The bronchial diameters exhibited considerable variation depending on both anatomical location and the pressure conditions under which measurements were obtained. Individual variations in measurements taken at identical locations under end-expiratory and peak inspirational (15 cmH_2O) conditions demonstrated certain variance.
Panopoulos et al. conducted comparable measurements of the feline bronchial tree [7]. Their study acquired measurements at various bronchial locations, encompassing a greater number of measurement sites (20 points) compared to our investigation (7 points). Due to the expanded number of measurement locations in the published literature, their findings provide a more comprehensive characterization of bronchial diameters throughout different regions of the bronchial tree [7]. Nevertheless, certain measurement sites in both studies correspond to nearly identical anatomical locations, offering cross-reference values that enable comparison between the two investigations. Both studies examined bronchial lumen diameter variation at 15 cmH_2O and the obtained results demonstrated notable similarities, suggesting that bronchi possess a considerable degree of resilience. This finding also highlights the challenge of establishing appropriate physiological reference values for normative baseline lumen diameter in feline patients.

In our research, we attempted to establish such a physiological baseline value by examining diameter variation among the 11 subjects under end expiratory pressure conditions. By calculating a statistical mean from these measurements, we determined that the mean baseline in our study ranged from 1.1 to 4.3 mm, depending on the bronchus in which it was measured.
In comparison to the previously established baseline values, our bronchial diameter measurements at various anatomical locations under 15 cmH_2O pressure conditions demonstrated a statistically significant increase.
This increase was determined by calculating the mean diameter change between the two ventilatory conditions, revealing that the bronchial lumen diameters exhibited dilation ranging from 26% to 91%. The smallest degree of dilation was observed in the right and left mainstem bronchi, which demonstrated 26% and 28% dilation, respectively. The bronchi of the right cranial, right caudal, left caudal, and accessory lobes exhibited a mean dilation of 65%. The mean bronchial dilation of all examined bronchi was 58%.

In the comparative study by Panopoulos et al., mean bronchial diameters ranged from 1.05 to 3.83 mm depending on the measurement site, whereas in the present investigation, these values ranged from 2.0 to 5.4 mm [7].
This regional heterogenicity indicates that the bronchial tree does not respond uniformly to pressure changes. Some regions demonstrate nearly a doubling of luminal diameter, while others show only slight expansion. Understanding these regional differences is crucial for accurate CT interpretation, as diagnostic significance may vary depending on anatomical location.
These findings have direct relevance to diagnosing bronchiectasis and bronchial collapse in clinical practice. Cats examined at end expiratory pressure may appear normal despite having pathology, while healthy cats imaged under positive pressure ventilation may show elevated measurements that might mimic a respiratory disease.

Comparable results have been reported by Oh et al. in healthy canine subjects [10]. Given that bronchomalacia and bronchial collapse represent significant pathological alterations in dogs, accurate baseline measurements are essential. Oh et al. documented a mean bronchial collapsibility of 38% in dogs, whereas the present study observed a bronchial collapsibility of 43% and mean bronchial dilation of 58% in Case 1 [10].
These findings underline the considerable interspecies variability in bronchial lumen dynamics and demonstrate that applying reference values across species may yield unreliable results due to inherent anatomical differences. Consequently, species specific baseline data are necessary to ensure diagnostic accuracy in veterinary respiratory imaging.

Our results may establish baseline parameters for how healthy feline bronchi respond to pressure variations, providing a reference framework for evaluating pathological changes. For instance, feline patients with bronchomalacia would be expected to demonstrate exaggerated collapse during expiration or abnormal expansion during inflation compared to these normative values we have presented. The challenge in clinical practice lies in distinguishing normal pressure induced variation from true pathological changes.
This study contributes by confirming that using vertebral body diameter as a normalization for measurements effectively controls BA ratio variability. The vertebral body represents a stable anatomical reference structure that remains constant regardless of respiratory phase or ventilatory pressure. Expressing bronchial and arterial dimensions as ratios to thoracic

vertebral width removes the confounding effects of individual size and pressure related differences.

Recent literature by Lee-Fowler et al. has examined broncho-vertebral (BV) ratios in healthy feline subjects [11]. Their findings demonstrated BV ratios ranging from 0.26 to 0.59 across different pulmonary lobes under 15 cmH_2O pressure conditions, while broncho-arterial (BA) ratios approximated 1.0 [11].
In the present study, Case 1 exhibited BA ratios of 1.14 and 1.36 under identical ventilatory conditions. This discrepancy suggests considerable variability in bronchial lumen measurements, particularly given the documented variation in bronchial artery diameter reported in the literature. The presence of multiple variable factors inherent to ratio calculations compromises the establishment of precise baseline values. Consequently, the BV ratio may offer superior reliability for establishing reference standards in healthy feline populations, thereby facilitating more accurate comparative assessments when evaluating patients with respiratory disease.

Based on these findings some practical recommendations rise for clinical thoracic CT interpretation in cats. Imaging should be performed under standardized ventilatory conditions. The measurements should be normalized to vertebral body diameter to account for size variation. Reference ranges should be region specific especially recognizing different lung lobes demonstrate different extent of normal pressure induced variation.

However, several limitations arise from this study. Primarily, the small sample size limited the scope of findings; a larger patient cohort would have yielded a broader range of results. Future research should establish species-specific reference values through separate studies examining healthy feline subjects by age and breed, followed by comparative investigations in diseased populations. This approach would enable the establishment of more precise baseline parameters from which pathological luminal changes can be definitively identified.
Available research on bronchial lumen variations in small animal medicine remains limited, with the majority of studies focusing on canine subjects. Comparative analysis with existing literature is hindered by the scarcity of scientific publications addressing bronchial luminal variations in feline patients.

These limitations highlight the need for future research comparing our present normative data with measurements obtained from feline patients with confirmed bronchiectasis or bronchomalacia. Such comparative studies would establish whether diseased airways exhibit altered pressure response patterns, quantify these differences and expand knowledge of feline respiratory tract mechanisms.

6. Conclusion

This study demonstrates that controlled intra-airway pressure significantly affects feline bronchial dimensions and BA ratios in healthy cats. Relatively modest bronchial dimensional changes can produce substantial BA ratio variation.

The present study also investigated inter individual variation in feline bronchial lumen diameter changes under end expiratory and 15 cmH_2O pressure conditions.

The collected data demonstrated the considerable difficulty in establishing a baseline reference value for healthy patients that could be applied in subsequent examinations. Although certain values may suggest pathological alterations, it is essential to perform additional diagnostic investigations to support such findings because measured values do not always represent pathognomonic changes.

However, due to the numerous variable factors that compromise the reliability of BA ratio measurements, adoption of the BV ratio as an alternative metric may provide greater precision in quantifying bronchial luminal diameter changes.

Nevertheless, we attempted to establish baseline reference values for application in future research or clinical settings to differentiate between healthy and diseased patients.

This study also highlights the importance of standardized imaging protocols and ventilatory pressure control in veterinary thoracic CT interpretation.

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8. Bibliography

1. Schulz RA, Stein JA, Pelc NJ (2021) How CT happened: the early development of medical computed tomography. J Med Imag 8:. https://doi.org/10.1117/1.JMI.8.5.052110

2. Boiselle PM (2008) Imaging of the Large Airways. Clinics in Chest Medicine 29:181–193. https://doi.org/10.1016/j.ccm.2007.11.002

3. Ohlerth S, Scharf G (2007) Computed tomography in small animals – Basic principles and state of the art applications. The Veterinary Journal 173:254–271. https://doi.org/10.1016/j.tvjl.2005.12.014

4. Masseau I, Reinero CR (2019) Thoracic computed tomographic interpretation for clinicians to aid in the diagnosis of dogs and cats with respiratory disease. The Veterinary Journal 253:105388. https://doi.org/10.1016/j.tvjl.2019.105388

5. Magder S (2007) Invasive Intravascular Hemodynamic Monitoring: Technical Issues. Critical Care Clinics 23:401–414. https://doi.org/10.1016/j.ccc.2007.07.004

6. Caccamo R, Twedt DC, Buracco P, McKiernan BC (2007) Endoscopic bronchial anatomy in the cat. Journal of Feline Medicine and Surgery 9:140–149. https://doi.org/10.1016/j.jfms.2006.10.003

7. Panopoulos I, Auriemma E, Specchi S, Diana A, Pietra M, Papastefanou A, Zini E, Cipone M (2019) 64-multidetector CT anatomical assessment of the feline bronchial and pulmonary vascular structures. Journal of Feline Medicine and Surgery 21:893–901. https://doi.org/10.1177/1098612X18807778

8. Reinero CR, Masseau I, Grobman M, Vientos-Plotts A, Williams K (2019) Perspectives in veterinary medicine: Description and classification of bronchiolar disorders in cats. Veterinary Internal Medicne 33:1201–1221. https://doi.org/10.1111/jvim.15473

9. Giglio RF, Winter MD, Reese DJ, Thrall DE, Abbott JR, Graham JP, Berry CR (2013) RADIOGRAPHIC CHARACTERIZATION OF PRESUMED PLATE-LIKE ATELECTASIS IN 75 NONANESTHETIZED DOGS AND 15 CATS. Vet Radiology Ultrasound 54:326–331. https://doi.org/10.1111/vru.12035

10. Oh D, Lee S, Kim S, Choen S, Choi M, Yoon J (2019) Computed tomographic bronchial collapsibility values over 50% may be detected in healthy dogs. Vet Radiology Ultrasound 60:28–37. https://doi.org/10.1111/vru.12692

11. Lee-Fowler TM, Cole RC, Dillon AR, Tillson DM, Garbarino R, Barney S (2017) High-resolution computed tomography evaluation of the bronchial lumen to vertebral body diameter and pulmonary artery to vertebral body diameter ratios in anesthetized ventilated normal cats. Journal of Feline Medicine and Surgery 19:1007–1012. https://doi.org/10.1177/1098612X16668931

12. Chen Y, Latisenko R, Lynch DA, Ciet P, Charbonnier J-P, Tiddens HAWM (2024) Effect of inspiratory lung volume on bronchial and arterial dimensions and ratios on chest computed tomography in patients with chronic obstructive pulmonary disease. Eur Radiol 35:2990–2998. https://doi.org/10.1007/s00330-024-11126-3

13. Makara M, Dennler M, Schnyder M, Bektas R, Kircher P, Hall E, Glaus T (2013) EFFECT OF VENTILATION TECHNIQUE AND AIRWAY DIAMETER ON BRONCHIAL LUMEN TO PULMONARY ARTERY DIAMETER RATIOS IN CLINICALLY NORMAL BEAGLE DOGS. Vet Radiology Ultrasound 54:605–609. https://doi.org/10.1111/vru.12073

14. Henao-Guerrero N, Ricco C, Jones JC, Buechner-Maxwell V, Daniel GB (2012) Comparison of four ventilatory protocols for computed tomography of the thorax in healthy cats. ajvr 73:646–653. https://doi.org/10.2460/ajvr.73.5.646

15. Won S, Yun S, Lee J, Lee M, Choi M, Yoon J (2017) High resolution computed tomographic evaluation of bronchial wall thickness in healthy and clinically asthmatic cats. The Journal of Veterinary Medical Science 79:567–571. https://doi.org/10.1292/jvms.16-0476

16. Reid LE, Ray Dillon A, Hathcock JT, Brown LA, Tillson M, Wooldridge AA (2012) HIGH-RESOLUTION COMPUTED TOMOGRAPHY BRONCHIAL LUMEN TO PULMONARY ARTERY DIAMETER RATIO IN ANESTHETIZED VENTILATED CATS WITH NORMAL LUNGS. Vet Radiology Ultrasound 53:34–37. https://doi.org/10.1111/j.1740-8261.2011.01870.x

17. Cannon MS, Wisner ER, Johnson LR, Kass PH (2009) COMPUTED TOMOGRAPHY BRONCHIAL LUMEN TO PULMONARY ARTERY DIAMETER RATIO IN DOGS WITHOUT CLINICAL PULMONARY DISEASE. Vet Radiology Ultrasound 50:622–624. https://doi.org/10.1111/j.1740-8261.2009.01592.x

18. Kim H, Kim YJ, Lee H, An T, Yu J, Yoon H, An G, Jung J, Chang J, Chang D (2018) Computed tomographic and radiographic bronchial collapse may be a normal characteristic of forced expiration in dogs. Vet Radiology Ultrasound 59:551–563. https://doi.org/10.1111/vru.12625

19. Montaudon M, Desbarats P, Berger P, De Dietrich G, Marthan R, Laurent F (2007) Assessment of bronchial wall thickness and lumen diameter in human adults using multi-detector computed tomography: comparison with theoretical models. Journal of Anatomy 211:579–588. https://doi.org/10.1111/j.1469-7580.2007.00811.x

20. Litmanovich D, O'Donnell CR, Bankier AA, Ernst A, Millett ME, Loring SH, Boiselle PM (2010) Bronchial Collapsibility at Forced Expiration in Healthy Volunteers: Assessment with Multidetector CT. Radiology 257:560–567. https://doi.org/10.1148/radiol.10100219

Thesis progress report for veterinary students

Name of student: Anna Buza

Neptun code of the student: VAOWME

Name and title of the supervisor: Peter Molnar DVM

Department: Surgery and Ophthalmology

Thesis title: Changes of bronchial luminal width as a function of intra-airway pressure in cats: a CT morphological study

Thesis progress report I. – 10th semester

	Timing			Topic / Remarks of the supervisor	Signature of the supervisor
	year	month	day		
1.	2024	03	01	Literature research	
2.	2024	03	20	Literature research	
3.	2024	04	16	Principles of CT diagnostics	
4.	2024	05	07	Literature review	
5.	2024	05	20	Discussion on the overall structure of the thesis	

Thesis progress grade achieved at the end of the first semester: 5

Thesis progress report II. – 11th semester

	Timing			Topic / Remarks of the supervisor	Signature of the supervisor
	year	month	day		
1.	2025	10	01	LITERATURE REVIEW	
2.	2025	10	30	DISCUSSION ON THE WRITTEN PARTS	
3.	2025	11	15	OVERVIEW OF THE CASESTUDY, CORRECTION	

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4.					
5.					

Thesis progress grade achieved at the end of the 11th semester: ……5……..

The thesis meets the requirements of the Study and Examination Rules of the University and the Guide to Thesis Writing.

I accept the thesis and found suitable to defence,

……
signature of the supervisor

Signature of the student: ……

Signature of the secretary of the department: ……

Date of handing the thesis in…11.28……..

ÁLLATORVOSTUDOMÁNYI EGYETEM Szabászeti és Szemészeti Tanszék és Klinika 1787 BUDAPEST

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