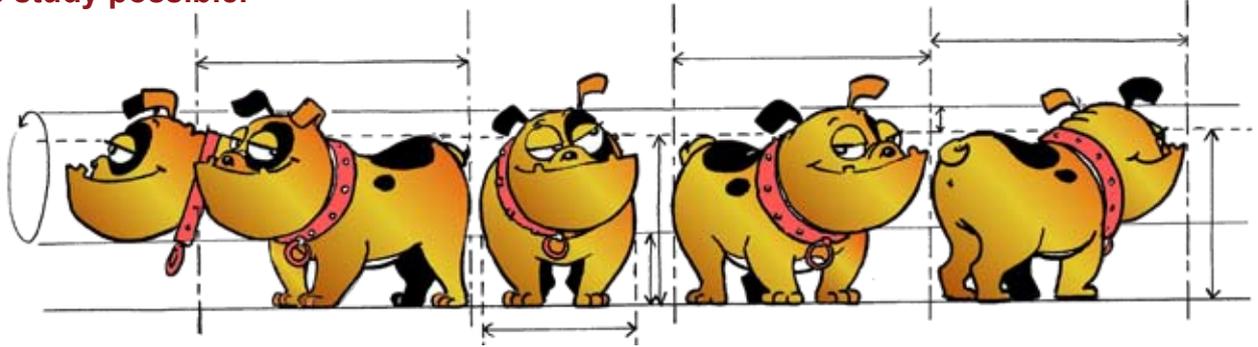


Trachea study: the results...

Before disclosing the results I wish to acknowledge the strong involvement of bulldogs owners (breeders and individuals) and your veterinarians, who lent themselves to the experience in order to learn more about our bulldogs' tracheas. A huge thank you to all who made this study possible.



Why did we carry out this study?

For the last few years, we have been in a difficult context since the English bulldog, a breed that is dear to us, is often pointed out for their health problems. The responsible leaders of the club have decided not to bury their heads in the sand, but to seriously focus on the bulldog's health. In the last couple of years, SCC also encourages clubs to implement a number of screenings to better select breeders. Such diagnostics should be targeted on the major breed-specific health problems.

In this respect, the club has assembled a "health" committee to reflect on and list the emerging health problems in our breed. The discussions were based on our personal experiences (breeders, individuals, veterinarians) and the results of the investigation "longevity-mortality" led by Sylvine Venetz.

In light of these reflections, two official screenings were established/introduced (patellar luxation and pulmonary stenosis and other heart disease) and an issue was raised about respiratory problems.

There are very few reliable and minimally invasive means of testing, which can be used for an official screening of

obstructive brachycephalic breeds syndrome (SORB). The best-known means, which is already used in some countries, is a size assessment of the trachea by measuring tracheal index on a radiograph of that trachea. The threshold value of this index was determined in 1982 on a lot of 39 bulldogs which only 7 were healthy. In this study, dogs with tracheal index <0.13 were considered to have tracheal hypoplasia. The club then reflected upon the importance of setting up an official screening based on the radiological evaluation of the tracheal index on the English bulldog.

The objectives of the trachea study

In view of the implementation of an official screening, it was necessary to check:

The reliability of this index to differentiate healthy dogs from those with respiratory symptoms

The reliability of the tracheal index to assess the actual size of the trachea

The reliability of the 0.13 threshold to distinguish healthy dogs from those carrying a SORB.

If the study concludes that these three parameters are reliable, the implementation of an official screening for the "size of the trachea" could then be considered.

The protocol

The protocol is to achieve a lateral radiograph of thorax and neck of over a year-old awake dog (Fig. 1a and b).

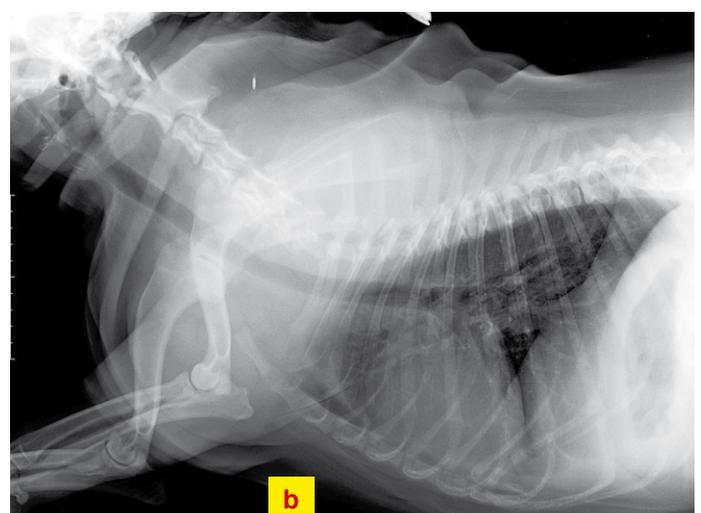
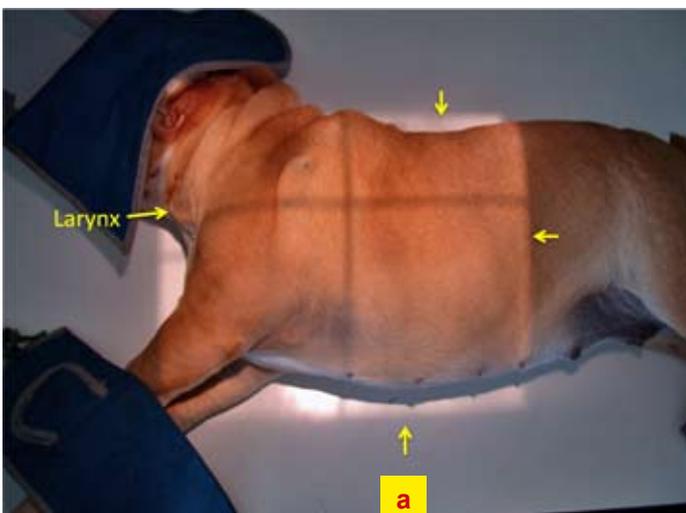


Fig.1: dog position to obtain radiograph (a) and radiograph (b).

The radiograph should be accompanied by a small form inquiring age, sex, weight, type of breathing and two chest girths, one measured at the point of the elbow and the other at the limit of mid-thorax (Fig.2 a, b and c).

Informations to be given with the radiography

Age :

Sex :

Accurate weight :

Type of breathing during physical effort :

- Normal
- Slightly noisy
- Noisy with production of phlegm

Girth measurement in cm :

- From the tip of the elbow:
- Mid-thorax :



a

c

Fig.2: Form to attach with the radiography (a) measuring the thoracic girth at the tip of the elbow (b), measurement of the thoracic girth at mid-thorax (c)

On these X-rays, the assessment of the trachea's size was carried out by two parameters:

- **tracheal index TD / TI** is the ratio between the tracheal diameter and the height of the breathing diaphragm, which are both measured at the first rib (Figure 3)
- **the diameter of the trachea** measured in mm at the first rib.

To be able to measure reliable lengths on an X-ray, it is imperative to have on the radiographic image a radio-opaque object of a known size (ruler, coin) in order to calibrate the picture. This helps to determine the actual size of a pixel on each image. The second parameter could therefore only be measured only if this size marker is present on the radiographs (Figure 3)..

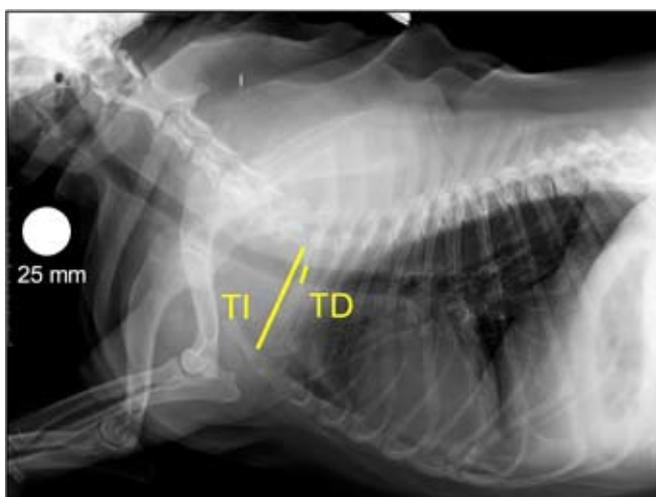


Fig.3: tracheal diameter (TD), Diameter of the Thoracic Inlet (IT) at the first rib. The template is a metal sphere of 25 mm in diameter.

All measurements were performed using ImageJ software. The silver radiograph films were digitalized.

The results

Over a period spanning from September 2013 to February 2016, 104 radiographies were received. Of these, had to be excluded:

- 8 radiographs due to a quality defect.
- 3 for lack of identification (sent by veterinarians with no detail).

- 21 as a result of incomplete data (they may be added to the study after more information).

The main quality defect, which prevented reading, was linked to an error in the dog's position. This failure resulted in a superposition of the forelimbs on thoracic inlet (especially the sternum) preventing the measurement of the tracheal index (Figure 4).



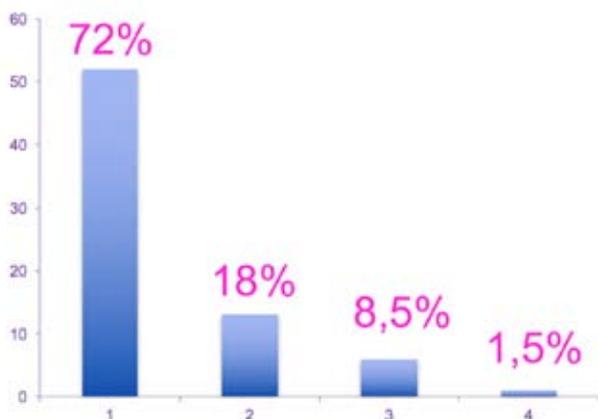
Fig.4: The left radiography is of good quality, the right radiography is excluded.

The study therefore examined the **72 remaining radiographies**.

The headcount was of 15 males (21%) and 57 females (79%), aged between 1 and 9 years old with an average of 3 years. The weight ranged from 18-33 kg with a mean of 24.7 kg. The weight of females ranged from 18 to 33 kg

with an average of 24.1 kg and that of males ranged from 22.4 to 30 kg for an average of 26.6 kg.

The distribution of breathing types is illustrated in fig.5. It shows a majority of dogs with normal breathing (72%) and 28% having mild to severe respiratory disorders



1. Normal
2. slightly noisy
3. Noisy 3
4. Noisy with mucus.

Fig.5: Breathing types distribution of dogs included in the study.

The index tracheal TD / IT ranged from .075 to 0.194 with an average of 0.133 (Fig.6 and 7)..



Low tracheal index



High tracheal index

Fig.6: Example of radiography of a dog with low tracheal index on the left and high on the right.

If one refers to the threshold limit of 0.13 for normal dogs, as Harvey published in 1982, 30% of dogs in the study would be defined as bulldogs affected by tracheal hypoplasia (Fig.7).

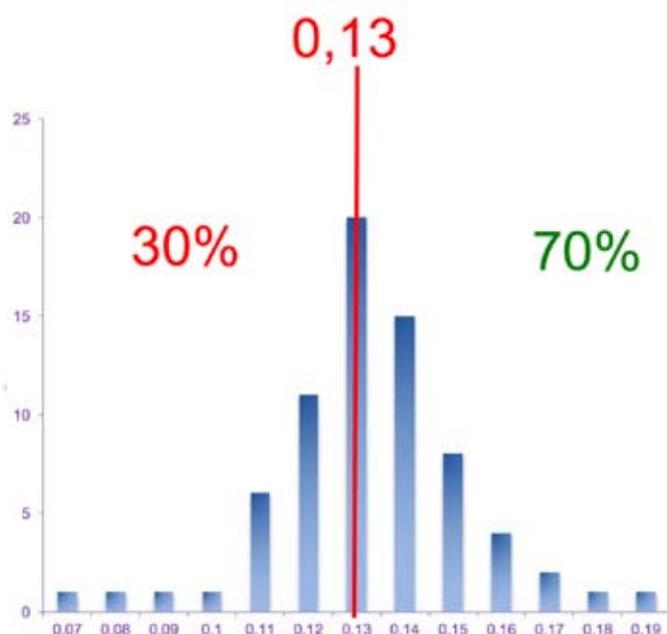


Fig.7: Distribution of tracheal index measured on 72 radiographs of the study.

Regarding the actual size of the trachea measured in mm at the thoracic inlet, only 16 radiographies showed a size template enabling its measurement. Of the 16 radiographies, the actual size of the trachea ranged from 8 to 13 mm with an average of 10 mm.

Question 1: Is there a correlation between the tracheal index and the type of breathing?

The correlation coefficient between the tracheal index and the type of breathing is 0.11, which indicates no correlation (Table 1).

This lack of correlation is confirmed by analysis of the distribution of breathing types within groups of dogs having a lower tracheal or an index greater than 0.13 (Fig.8). There is a similar distribution in the 2 groups.

21 bulldogs (30%)
Index < 0,13

51 bulldogs (70%)
Index > 0,13

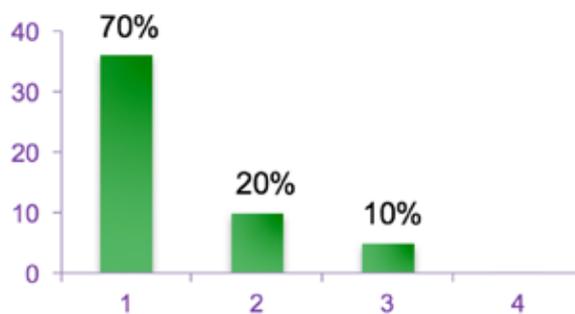
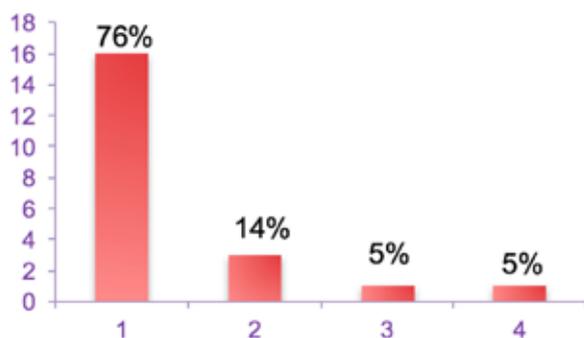


Fig.8: Distribution of respiratory type is similar in the group of dogs with tracheal index <0.13 and one with a tracheal index > 0.13.

Breathing Type: 1 Normal; 2 slightly noisy; Noisy 3; 4 Noisy with mucus.

The tracheal index does not seem to be efficient to distinguish the normal breathing from the ones, which present respiratory problems. To state this notion with certainty, it would however be necessary to include more dogs with respiratory symptoms for greater statistical power

Paramètres	Coefficient de corrélation
TD/TI versus sexe	0,05
TD/TI versus âge	0,22
TD/TI versus poids	0,14
TD/TI versus type de respiration	0,11
TD/TI versus périmètre à la pointe du coude	0,03
TD/TI versus périmètre thoracique	0,08
Type de respiration versus périmètre (coude)	-0,32
Type de respiration versus périmètre (thorax)	-0,29
Périmètre (coude) versus périmètre (thorax)	0,79

Table 1: Correlation coefficient between the different parameters evaluated in the study.
A coefficient close to 1 shows a strong proportional link between the two parameters.
A coefficient close to -1 shows a strong inverse link between the two parameters.
A coefficient close to 0 shows a lack of connection between the two parameters.

Question 2: Is there a link between tracheal index and certain physical characteristics of the dog?

The analysis of correlation coefficients (Table 1) shows that there is no link between tracheal index and sex, age, weight, type of breathing or chest girth measurement.

However, a correlation coefficient close to 0.80 shows that the shape of the thorax evolves harmoniously between the tip of the elbow to mid-chest. The two measures are fairly proportional.

On the other hand, it is interesting to note that the coefficients of correlation between the type of breathing and chest girth are negative. Although the correlations are weak and not significant from a statistical point of view, they help to show a tendency towards an alteration of the respiratory type on dogs with small thorax (Fig.9).

Also it is worth noting that the chest girth from the tip of the elbow tends to be slightly higher than the mid-thorax girth in dogs with good respiratory type (1 and 2). This inclination confirms the “pear” shape of our bulldogs, while this seems to be reversing for dogs with abnormal respiratory type (3 and 4) and all the more so when the respiratory type is severe. This data is not statistically significant but could serve as a basis for reflection. Indeed, it is not rare to see in bulldogs with breathing issues, a chest that widens backwards and a strong transition with a narrow abdomen. The question is whether the shape of the chest is a cause or a consequence of breathing difficulties if this trend were to be confirmed.

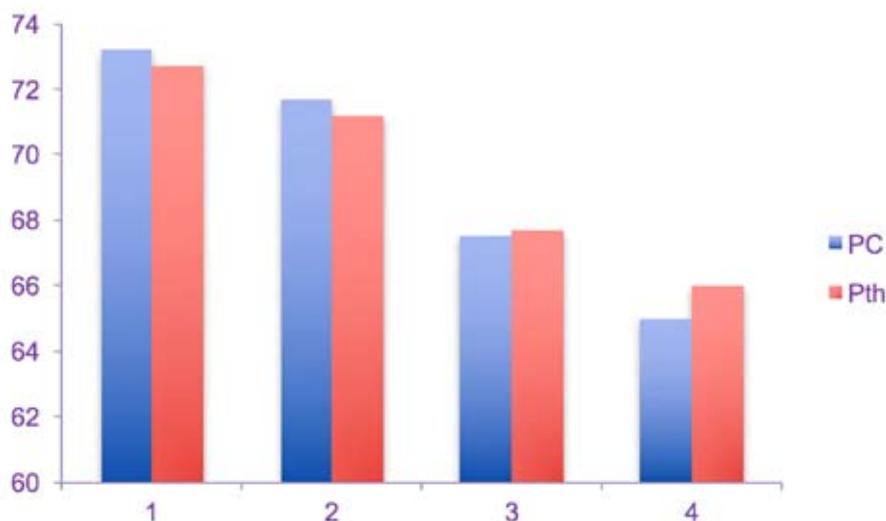


Fig.9: Evolution of chest girths at the tip of the elbow (PC) and mid-thorax (PTh) according to the respiratory type.

Breathing Type: 1 Normal - 2 slightly noisy - Noisy 3 - 4 Noisy with mucus

Question 3: How can we explain that the tracheal index is not reliable to estimate the size of the trachea on a bulldog?

It is likely that this lack of reliability is related to the measurement itself. As a matter of fact, the presence of air in the

oesophagus in some cases can be an obstacle to measure the tracheal diameter (Fig.10).

Fig.10: the presence of air in the oesophagus makes it difficult to measure accurately the tracheal diameter at the entrance of the thorax in order to determine the tracheal index.



Furthermore, a recent study by a Swedish team has shown the difficulty of being repeatable when conducting such measures. Even imaging specialists with powerful experience, have obtained an insufficient intraobserver agreement for repeated measurements were repeated several times. (Ingman, J. et al. *Comparison between tracheal ratio methods used by three observers at three occasions in English Bulldogs. Acta Veterinaria Scandinavica* 2014 56:79)

It has also been shown recently that the size of the trachea is much more reliable when shown by a CT scan than by radiographic examination. (Kaye, BM et al. *CT, radiographic and endoscopic tracheal dimensions in English bulldogs with grade 1 clinical signs of brachycephalic airway syndrome. Vet Radiol Ultrasound* 2015 56 (6) p 609-16). Unfortunately this scanner examination requires general anaesthesia and is much more expensive than a simple X-ray, which does not allow us to consider it for the achievement of the official screening.

The study of X-rays also helps explain why the tracheal index is not a good way to assess the size of the trachea, especially for the English bulldog.

The use of an index rather than a direct measurement is used to weigh the measurement of the tracheal diameter depending on the dog's size. It is obvious that the tracheal diameter of a large dog cannot be compared to that of a small dog. For this we create a report that takes into account the dog's size and thus to compare the tracheal index of any dog size. Amongst the different ratios studied, TD / TI had been shown as the most reliable. However, for the weighting to be accurate, it is necessary that the height of the thorax (TI) actually and linearly varies according to the dog's size, which implies that the morphology of the thorax is evenly homogeneous from one dog to another.

But the analysis of X-rays shows that there is a very strong variability of thoracic shape, regardless of the size (Fig.11)..



non brachycéphalic breed



Bulldog anglais

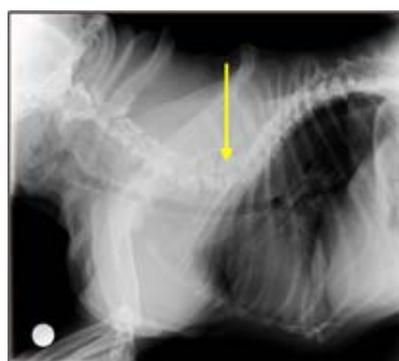
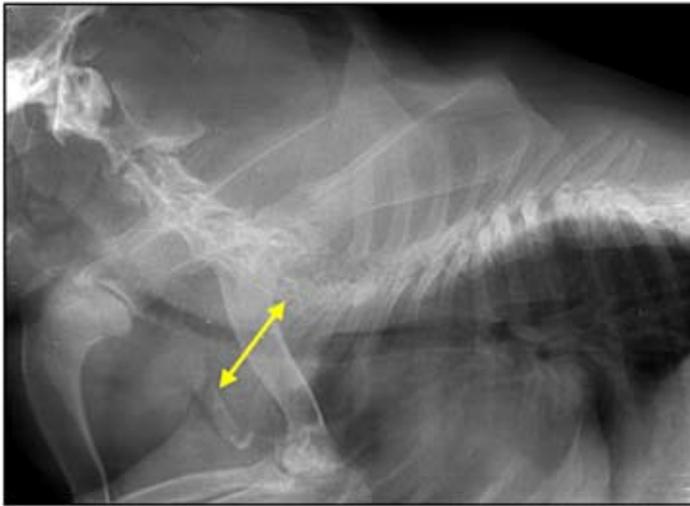


Fig.11: Radiographies showing the difference between forms of chest of 3 dogs

Thus, 2 dogs that have a similar trachea size but a different thorax shape will have a different tracheal index (Fig.12).



Trachéal index = 0,18



Trachéal index= 0,13

Fig.12. Both dogs have similar tracheal size but very different chest forms. The dog's low thorax entrance on the left picture artificially increases the tracheal index compared to the dog on the right one.

Conclusion

This study confirmed that the tracheal index TD / TI is not a good setting to assess the size of the trachea. The establishment of a formal screening protocol based on this parameter would have resulted in the exclusion of 30% of bulldogs for tracheal hypoplasia which 76% had normal breathing and 14% a slightly noisy breathing.

So today there is no “gold standard” to properly assess the size of the trachea and even less to distinguish a dog with a tracheal hypoplasia from a normal dog.

In addition, various clinical studies have shown that dogs suffering from isolated “tracheal hypoplasia” were not necessarily clinically affected unlike those with a brachycephalic syndrome. Moreover, the air resistance during inhalation is 79% due to the nasal cavity, 6% to the larynx and only 15% to the lower respiratory tract. At expiration, the air resistance is 74% due to the nasal cavities, 3% to the larynx and 23% to the lower respiratory tract.

A question can thus arise: Is the size of the trachea the most limiting parameter?

Would the shape and the thoracic volume play a role on the respiratory function? What about the nasal cavities?