

# Evaluation of the right ventricular function in dogs with brachycephalic syndrome before and after rhinoplasty

Avaliação da função ventricular direita em cães portadores da síndrome do braquicefálico antes e após rinoplastia

Daniel Carvalho Hainfellner<sup>1\*</sup>, Mário dos Santos Filho<sup>1</sup>, Bruno Alberigi<sup>2</sup>, Alexandre José Rodrigues Bendas<sup>2</sup>, Carolina do Valle Aben Athar<sup>1</sup>, Nathalia Marques de Oliveira Lemos<sup>3</sup>, Karen Denise da Silva Macambira Barbosa<sup>3</sup>, Juliana Silva Do Carmo<sup>3</sup>, Ana Maria de Barros Soares<sup>4</sup>, Aguinaldo Francisco Mendes Junior<sup>5</sup>, Cristiano Chaves Pessoa da Veiga<sup>2</sup>, Daniel de Almeida Balthazar<sup>2</sup> & Jonimar Pereira Paiva<sup>2</sup>

<sup>1</sup>Veterinarian, MSc, Programa de Pós-Graduação em Medicina Veterinária (PPGMV), Departamento de Medicina e Cirurgia Veterinária (DMCV), Instituto de Veterinária (IV), Universidade Federal Rural do Rio de Janeiro (UFRRJ), Seropédica, RJ, Brazil

<sup>2</sup>Veterinarian DSc, DMCV, IV, UFRRJ, Seropédica, RJ, Brazil

<sup>3</sup>Veterinarian, Resident, Programa de Residência em Medicina Veterinária - Cardiologia e Doenças Respiratórias de Animais de Companhia, DMCV, IV, UFRRJ, Seropédica, RJ, Brazil

<sup>4</sup>Veterinarian DSc, Centro de Ciências Médicas, Faculdade de Veterinária, Universidade Federal Fluminense (UFF), Niterói, RJ, Brazil

<sup>5</sup>Veterinarian MSc, Programa de Pós-Graduação em Medicina Veterinária - Clínica e Reprodução Animal, UFF, Niterói, RJ, Brazil

## Abstract

Brachycephalic dogs are usually affected by primary and secondary anatomical changes in the airways that contribute to the brachycephalic syndrome. Chronically, these changes contribute to an increase in pulmonary arterial pressure and right cardiac overload (*cor pulmonale*). The right cardiac function in 17 dogs with brachycephalic syndrome was assessed using echocardiography before, and at 30 and 60 days after rhinoplasty. The maximum pulmonary systolic flow velocity, the pressure gradient between the AP and RV (GrFP), the right ventricular systolic function (tricuspid ring systolic excursion (TAPSE), the variation of the right ventricular area (FAC), the velocity of the systolic displacement of the right ventricular myocardium (S') by tissue Doppler) and right ventricular diastolic function (transtricuspid flow and the relationship between the E and A waves, evaluation of the E' and A' waves using tissue Doppler of the free wall of the right ventricle) were evaluated. The right ventricular fractional area, velocity, and pressure gradient of pulmonary arterial flow showed the best sensitivity in these analyses. The present study reinforces the concept that obstructions in the anterior airways contribute to pulmonary hypoxia. However, the correction of these obstructions proved to be beneficial in the reduction of right heart overload.

**Keywords:** *Cor pulmonale*, pulmonary hypertension, pulmonary vascular resistance, echocardiogram.

## Resumo

Os cães braquicefálicos geralmente são afetados por alterações anatômicas primárias e secundárias nas vias aéreas, que contribuem para a síndrome braquicefálica. Essas alterações, cronicamente, contribuem para o aumento da pressão arterial pulmonar e sobrecarga cardíaca direita (*cor pulmonale*). Para avaliar a função cardíaca direita em cães com síndrome braquicefálica, 17 cães com essa condição foram avaliados antes, e 30 e 60 dias após a cirurgia de rinoplastia, por meio de ecocardiografia. A velocidade máxima do fluxo sistólico pulmonar (e o gradiente de pressão entre AP e VD (GrFP) foram avaliados, bem como a função sistólica do ventrículo direito (deslocamento sistólico do anel tricúspide (TAPSE), a variação fracional da área ventricular direita (FAC), e a velocidade do deslocamento sistólico do miocárdio ventricular direito (S') pelo Doppler tecidual) e a função diastólica do ventrículo direito (fluxo transtricúspide e relação entre as ondas E e A, avaliação das ondas E' e A' por Doppler tecidual parede livre do ventrículo direito). Os índices que apresentaram melhor sensibilidade nessas análises foram a área fracional do ventrículo direito, a velocidade e o gradiente de pressão do fluxo arterial pulmonar. O presente estudo reforça o conceito de que obstruções nas vias aéreas anteriores contribuem para a hipóxia pulmonar e a correção das obstruções mostraram-se benéficas na redução da sobrecarga cardíaca direita.

**Palavras-chave:** *Cor pulmonale*, hipertensão pulmonar, resistência vascular pulmonar, ecocardiograma.



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### \*Correspondence

Daniel Carvalho Hainfellner  
Programa de Pós-Graduação em Medicina Veterinária, Instituto de Veterinária, Universidade Federal Rural do Rio de Janeiro - UFRRJ  
Rodovia BR 465, Km 7, Campus Universitário, Bairro Zona Rural  
CEP 23897-000 - Seropédica (RJ), Brasil  
E-mail: dhainfellner@gmail.com

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## Introduction

Brachycephalic dogs commonly present with anatomical changes that lead to upper airway obstruction, causing a clinical syndrome known as brachycephalic syndrome (Dupré & Heidenreich, 2016; Meola, 2013; Oechtering, 2010). The increase in negative pressure and swirling of the airflow inside the airways occurs as a result of the chronic obstructive process, leading to a decrease in the patient's quality of life (Oechtering, 2010).

Arteriolar vasoconstriction and consequent pulmonary hypertension occur as a result of upper airway obstruction (Park & Troxler, 2002; Abd El-Moneim et al., 2009). This leads to an overload of the right heart chambers, and consequently the development of *Cor pulmonale* (Boon, 2011; Carvalho et al., 2002; Tilley, 2002). These changes can be identified by echodopplercardiography when the right ventricular function is assessed (Boon, 2011; Madron, 2016).

This study aimed to evaluate the repercussion of airway obstructions in the right heart chamber, from a morphofunctional point of view, by comparing the results of echocardiography evaluation before and after corrective surgery by laser rhinoplasty.

## Material and methods

The project was submitted to the Ethics Committee on Animal Use of the Instituto de Veterinária da Universidade Federal Rural do Rio de Janeiro and was evaluated and approved under number 5490040118. Animals were included in the study after obtaining consent from their owners.

Animals with nostril stenosis from the clinical care of the veterinary hospital of Universidade Federal Rural do Rio de Janeiro were included, after pre-anesthetic evaluation consisting of physical examination, electrocardiography, chest radiography, complete blood count, and measurement of serum levels of alkaline phosphatase, alanine aminotransferase, BUN, and creatinine. Heartworm screening was performed using the modified Knott method (Newton & Wright, 1956) and circulating antigens of *Dirofilaria immitis* using the ELISA technique (Snap 4DX Plus®, IDEXX Laboratories, Inc., USA). Patients with cardiorespiratory or systemic diseases detected on clinical or complementary examinations were excluded from the study.

Echocardiography evaluation was performed using the Esaote MyLab Gamma® device (Genoa, Italy) with two sectoral transducers (1-4 MHz and 3-11 MHz). Echocardiography was performed according to the standards recommended by the Echocardiography Committee of the Specialty of Cardiology, American College of Veterinary Internal Medicine, with modifications suggested by Chetboul (2016).

The morphology and function of the left atrioventricular and aortic valves of the left cardiac chambers were also evaluated. In addition, the diastolic function was evaluated. Systolic function was evaluated in the M-mode using the Teicholz method. If any changes that could affect right ventricular function were detected, the animal was excluded from the study.

For the assessment of pulmonary flow, the viewing window was the left cranial parasternal view of the right ventricular outflow tract long axis, placing the recording zone within the pulmonary valve area. The maximum transpulmonary flow velocity (VmP) and the pressure gradient between the pulmonary artery and the right ventricle (GrP) were evaluated.

To assess the right ventricular systolic function, we evaluated the following: (i) the systolic excursion of the tricuspid annular plane (TAPSE), (ii) the fractional area variation (FAC), and (iii) the velocity of the systolic displacement of the right ventricular myocardium (S') by tissue Doppler. The values considered normal for TAPSE were related to the animal's weight (3 kg = 6.6 to 10.6 mm, 4 kg = 7.2 to 11.5 mm, 5 kg = 7.7 to 12.3 mm, 7 kg = 8, 5 to 13.6 mm, 9 kg = 9.2 to 14.7 mm and 12 kg = 10 to 16 mm) (Madron, 2016), as well as the FAC values (3 kg = 41.7 to 69.1%, 4 kg = 40.5 to 67.2%, 5 kg = 39.6 to 65.8%, 7 kg = 38.4 to 63.7%, 9 kg = 37.4 to 62.2% and 12 kg = 36.4 to 60.5%) (Madron, 2016). The velocity of the right ventricular systolic displacement was considered normal when it was above 0.12 m/s (Chetboul et al., 2005).

To evaluate the diastolic function of the RV, transtricuspid flow and the E/A ratio waves were evaluated, in addition to the E'/A' ratio waves using tissue Doppler of the free wall of the right ventricle close to the tricuspid ring. The E/A ratio waves in the transtricuspid flow and E'/A' waves were considered normal when the values were between 1.12 and 1.80 (Madron, 2016).

On the day of the surgical correction of nostril stenosis, patients were directed to an air-conditioned room at 20°C and free from stressful stimuli. Morphine (1 mg/kg IV), propofol induction (3 mg/kg IV), and 1.5% isoflurane were used as pre-anesthetic medications.

Rhinoplasty was performed using the nostril wing correction technique and the removal of excess tissue from the nasal vestibular region. A carbon infrared diode laser (Vetlaser®, Brazil) with a wavelength of 808 nm ± 10 nm and useful power of 9 W ± 20%, with 400 µm or 600 µm diameter fiber was used. After completion of the procedure, dexamethasone (1 mg/animal/IV) was administered, and the animals were released after complete recovery from anesthesia.

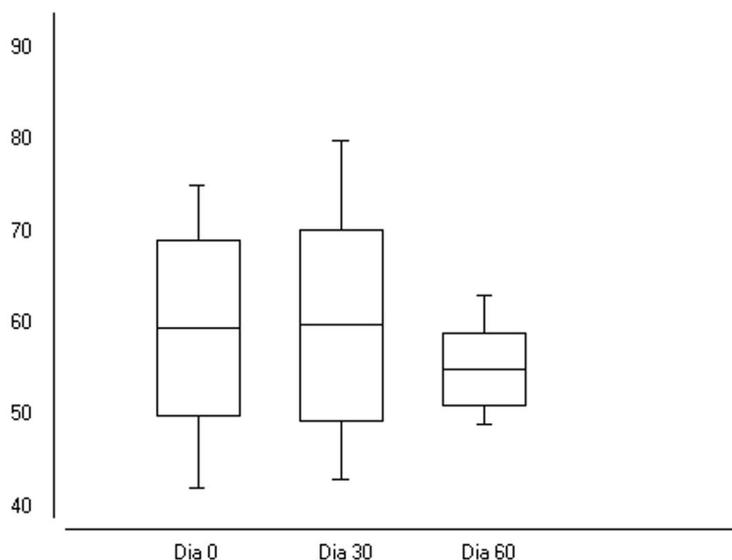
Dipyron (25 mg / kg / PO / BID / 5 days); cephalexin (30 mg / kg / PO / IDB / 15 days); metoclopramide hydrochloride (0.5 mg / kg / PO / 7 days); omeprazole (1 mg / kg / PO / SID / 7 days) and beclomethasone dipropionate (400 mcg diluted in 2 ml saline / SID / 7 days) via nebulization were prescribed. The patient underwent echocardiographic examination 30 and 60 days after the procedure.

The Kolmogorov-Smirnov test was used to analyze the normal distribution of the data. The student's *t*-test was used to analyze the normal data with repeated measures. The data that did not present a normal distribution were analyzed using the Friedman test in order to verify possible significant statistical differences between the rankings (values) at different moments of the treatment. A significance level of 5% was considered. SPSS®/IBM program version 26.0 was used.

## Results

Sixteen dogs were included in the study. Of the 16 dogs, 25% (n = 4) were of the Pug breed and 75% (n = 12) were French Bulldogs. Of these, 56.3% (n = 9) were male and 43.7% (n = 7) were female. The average age of the animals included in the study was 1.7 ± 1.3 years old.

The assessment of the ability of the right ventricle to pump blood for systemic circulation adequately (systolic function), showed that the mean values of TAPSE on days 0 ( $\bar{x}$  = 9.8 mm), 30 ( $\bar{x}$  = 10.7 mm), and 60 ( $\bar{x}$  = 11.9 mm) were similar (Fr = 2,774; p = 0.250). A difference was observed in the values of FAC between days 0 ( $\bar{x}$  = 59.6%) and day 60 ( $\bar{x}$  = 55%) (Fr = 10.750; p = 0.005) (Figure 1). The values of the S wave were similar on days 0 ( $\bar{x}$  = 14.6 cm/s), day 30 ( $\bar{x}$  = 13.8 cm/s), and on day 60 ( $\bar{x}$  = 14 cm/s) with no difference (Fr = 1.200; p = 0.549). The values of each index evaluated on days 0, 30, and 60 of the rhinoplasty are shown in Tables 1 and 2. The results of the comparison of systolic function over time are shown in Table 3.



**Figure 1.** Box plot of the means, standard deviations, minimum and fractional variation of the right ventricular area of dogs that underwent rhinoplasty, on days 0, 30, and 60.

**Table 1.** Spectral Doppler values of right ventricle diastolic function in the 16 brachycephalic animals at three different time points of the rhinoplasty (Day 0, Day 30, and Day 60).

Animal	E wave (m/s)			A wave (m/s)			E/A ratio		
	D0	D30	D60	D0	D30	D60	D0	D30	D60
1	74	59	47.1	52	50	35.3	1.42	1.18	1.33
2	64	63	73.6	50	50	49	1.27	1.24	1.59
3	88	78.5	100.1	74	71.6	79.5	1.2	1.1	1.26
4	58	65.7	53	41	37.3	43.2	1.4	1.76	1.23
5	43	55.9	48.1	41	48.1	41.2	1.05	1.16	1.14
6	70	77.5	54.9	60	73.6	39.2	1.6	1.05	1.4
7	43.2	46	50	32.4	47	45	1.33	0.99	1.11
8	51	52	56	32.4	42	46	1.8	1.26	1.2
9	62.8	52	61	50	44	45	1.25	1.17	1.36
10	46.1	34	49	38.3	37	40	1.21	0.9	1.22
11	53.8	48.1	55	42.6	38.3	43	1.26	1.26	1.28
12	98.1	91.2	58	69.7	66.7	63	1.41	1.36	0.91
13	65.7	80.5	78	55.9	70.6	66	1.18	1.14	1.19
14	51	58	55	43	40	30	1.18	1.44	1.86
15	68.7	72.6	61	52	54.9	59	1.32	1.32	1.04
16	75.5	48.1	66	57.9	34.3	47	1.31	1.4	1.4

**Table 2.** Spectral Doppler values corresponding to the right ventricle systolic function evaluated in the 16 brachycephalic animals at three different moments of rhinoplasty (Day 0, Day 30, and Day 60).

Animal	TAPSE (mm)			FAC (%)			Onda S (cm/s)			VmP (cm/s)			GrP (mmHg)		
	D0	D30	D60	D0	D30	D60	D0	D30	D60	D0	D30	D60	D0	D30	D60
1	9.2	10.7	6.9	71%	76%	61%	8	10.4	11.2	73	99	95.2	2.1	3.9	3.6
2	16.8	10.8	10.8	62%	70%	54%	21	20	14.1	130	124	125.6	6.8	6.1	6.3
3	8.6	12.5	16.4	67%	60%	56%	27	17.9	18.8	130	120.7	111.9	6.8	5.8	5
4	7.8	9.1	6	60%	53%	52%	16	12.6	14	94	95.2	96.2	3.5	3.6	3.7
5	9.9	10	9.1	66%	80%	63%	15	18.2	10.5	130	110.9	113.3	6.8	4.9	5.1
6	9.1	10.9	9.5	75%	48%	54%	14	16.9	7.8	143	126.6	133.4	8.2	6.4	7.1
7	9.5	17.4	12.5	55%	52%	51%	9	15	14	108	93	93	4.7	3.5	3.4
8	9.7	10.1	13	52%	56%	54%	9.9	10	10	68.7	81	81	1.9	2.6	2.6
9	9.5	13.1	13.1	62%	55%	57%	16.5	15	12	149	106	105	8.9	4.5	4.4
10	9.2	8	13.4	42%	57%	52%	11.8	12	12	81.1	93	84	2.6	3.5	2.8
11	9.9	9.6	12.5	55%	62%	54%	11.2	9.6	11	148	104	98	8.8	4.3	3.9
12	9.3	6.9	14	51%	59%	57%	14.5	12.9	18	111.9	117.7	132	5	5.5	6.9
13	8.6	8.1	14	72%	61%	49%	15.9	14.8	17	131.5	115	91	6.9	5.2	3.3
14	9.1	14	12.8	44%	51%	58%	21.6	14	11	125.6	81	123	6.3	2.6	6
15	9.7	9	13.2	56%	43%	50%	11.2	11.4	26	123.6	122.6	113	6.1	6	5.1
16	8.6	8.6	13.1	63%	74%	58%	11.3	9.8	17	104	104	88	4.3	4.3	3.1

TAPSE = systolic excursion of the tricuspid annular plane; FAC, fractional area variation of the right ventricle; VmP, maximum transpulmonary flow velocity; GrP, pressure gradient between the pulmonary artery and the right ventricle.

**Table 3.** Comparison between the right ventricular assessment methods performed on day 0 and day 60 in dogs submitted to rhinoplasty, compared by the Friedman test (Fr) and the student's *t*-test.

Assessment methods of the right ventricle	Fr (%)	p valor
TAPSE	2.774	0.250
FAC	10.750	0.005
S' wave	1.200	0.549
	T	p valor
E/A ratio	0.552	0.589
E'/A' ratio	0.475	0.642
VmP	1.9855	0.0328
GrP	2.2406	0.0203

TAPSE = systolic excursion of the tricuspid annular plane; FAC = fractional area variation of the right ventricle; VmP = maximum transpulmonary flow velocity; GrP, pressure gradient between the pulmonary artery and the right ventricle.

When the capacity of the right ventricle to relax, allowing ventricular filling (diastolic function), was assessed, the mean values of the E/A ratio were similar, being 1.30 on day 0; 1.20 on day 30; and 1.28 on day 60 (Table 1). A similarity was observed in the evaluation of the E' / A' ratio, which was 1.3 on day 0; 1.2 on day 30, and 1.8 on day 60 (Table 1).

In the assessment of blood pumped from the right ventricle through the pulmonary artery (pulmonary flow), when the VmP was compared, a difference was observed between day 0 and day 30 ( $t = 1.8971$ ;  $p = 0.0386$ ) and between day 0 and day 60 ( $t = 1.9855$ ;  $p = 0.0328$ ), with no difference between days 30 and 60 ( $t = 0.1742$ ;  $p = 0.432$ ). When assessing the GrP, a difference was observed between day 0 and day 30 ( $t = 2.267$ ;  $p = 0.0193$ ) and day 0 and day 60 ( $t = 2.2406$ ;  $p = 0.0203$ ), and as observed with VmP, there was no difference between day 30 and day 60 ( $t = 0.083$ ;  $p = 0.4672$ ).

## Discussion

Among the animals included in the study, no difference was observed in the systolic function of the right ventricle when assessed using TAPSE and by the S-wave velocity. It was inferred from these results that right ventricular overload was not detected by these methods before surgery. It is noteworthy that the mean age of the animals included in the study ( $1.7 \pm 1.3$  years) may also represent the fact that the sensitivity of these evaluations increases with chronicity and progression of *cor pulmonale* (Lira-Filho et al., 2009). Nonetheless, the FAC proved to be sensitive when detecting differences between day 0 and day 60. It was observed that on day 0, the myocardium presented values above expectations, which normalized 60 days later. This phenomenon could be due to the correction of the upper airway obstructions, which tend to reduce pulmonary vasoconstriction and, consequently, pulmonary vascular resistance. These events ultimately reduce the effort that the right ventricle needs to exert (Abd El-Moneim et al., 2009).

A study correlating the right ventricular end-diastolic area (RVEDA) suggested that it is a more accurate assessment of the right ventricular overload (Vezzosi et al., 2018) since TAPSE and FAC results are controversial in the literature (Pariat et al., 2012; Tidholm et al., 2015; Visser et al., 2016; Poser et al., 2017). Although this assessment was not performed in the present study, it is possible that it will not demonstrate significant results. This is because Vezzosi et al. (2018) showed that the statistical correlation of this measure was only positive in animals with moderate-to-severe pulmonary hypertension. However, the animals evaluated in the present study did not show signs of moderate or severe pulmonary hypertension.

Although the occurrence of diastolic dysfunction of the right ventricle in dogs with upper airway obstruction disease is not yet well defined, in the present study, the animals were normal before and after surgery. This indicates that the respiratory changes in the studied dogs had no significant impact. However, as discussed in the results of the right ventricular systolic

function, the sample of young animals may have influenced this result, since the chronicity of obstructive processes can culminate in chronic pulmonary changes and consequent *cor pulmonale* and diastolic dysfunction (Abd El-Moneim et al., 2009; Kim, 2018; Koc et al., 2012; Park & Troxler, 2002)

The evaluation of VmP and GrP in the present study showed that there was an increase in these parameters after surgical correction of respiratory changes. This finding reinforces the results of the evaluation of the FAC, where an increase in pulmonary vascular resistance secondary to upper airway obstruction, even without the development of pulmonary hypertension, caused an increase in pulmonary resistance, leading to greater resistance to blood pumping through the right ventricle (Pyle et al., 2004). Thus, after the improvement of pulmonary hypoxia, and consequently a decrease in afterload, there is less pulmonary resistance, improving the speed and pressure gradient of the pulmonary flow (Abd El-Moneim et al., 2009).

Knowing that the development of pulmonary vascular lesions related to *cor pulmonale* and mainly to brachycephalic syndrome is slow and chronic (Canola et al., 2018), the age of the animals and the short study period may have been crucial for the non-observation of other changes in the assessment indexes of the right ventricle. Therefore, further studies in this area are recommended.

## Conclusion

The present study suggests that in the dogs evaluated, nostril stenosis contributed to right heart overload since after correction of this alteration, the values of the presented right ventricular fractional area and the velocity and pressure gradient of pulmonary arterial flow improved.

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## Ethics statement

This study was authorized by the animals owners through formal consent for disclosure of data and images for academic purposes.

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## Conflicts of interests

DCH, MSF, BA, AJRB, CVAA, NMOL, KDSMB, JSC, AMBS, AFMJ, CCPV, DAB and JPP no conflict of interest.

## Authors' contributions

DCH, MSF, BA, AJRB, CVAA, NMOL, KDSMB, JSC, AMBS, AFMJ, CCPV and JPP - drafted the manuscript and approved the version to be published. AMBSA - performed the surgical procedure. DCH, MSF, NMOL, KDSMB, JSC, AFMJ and JPP - Performed clinical evaluation and data acquisition of the animals in the study. BA, CVAA - performed and interpreted the cardiologic exams. BA, AJRB - performed and interpreted statistic analysis. DCH, BA and AJRB - Interpreted the complete data.

## Availability of complementary results

All information obtained as a result of the study is included in the manuscript.

**Place where the study was conducted:** The animals reported were treated at the Veterinary Hospital of the Universidade Federal Rural do Rio de Janeiro.

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