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Retrospective Review of Congenital Heart Disease in 976 Dogs

P. Oliveira, O. Domenech, J. Silva, S. Vannini, R. Bussadori, and C. Bussadori

Background: Knowledge of epidemiology is important for recognition of cardiovascular malformations.

Objective: Review the incidence of congenital heart defects in dogs in Italy and assess breed and sex predispositions.

Animals: Nine hundred and seventy-six dogs diagnosed with congenital heart disease (CHD) of 4,480 dogs presented to Clinica Veterinaria Gran Sasso for cardiovascular examination from 1997 to 2010.

Methods: A retrospective analysis of medical records regarding signalment, history, clinical examination, radiography, electrocardiography, echocardiography, angiography, and postmortem examination was performed. Breed and sex predisposition were assessed with the odds ratio test.

Results: CHD was observed in 21.7% of cases. A total of 1,132 defects were observed with single defects in 832 cases (85%), 2 concurrent defects in 132 cases (14%), and 3 concurrent defects in 12 cases (1%). The most common defects were pulmonic stenosis (PS; 32.1%), subaortic stenosis (SAS; 21.3%), and patent ductus arteriosus (20.9%), followed by ventricular septal defect (VSD; 7.5%), valvular aortic stenosis (AS; 5.7%), and tricuspid dysplasia (3.1%). SAS, PS, and VSD frequently were associated with other defects. Several breed and sex predispositions were identified.

Conclusions and Clinical Relevance: The results of this study are in accordance with previous studies, with slight differences. The breed and sex predilections identified may be of value for the diagnosis and screening of CHD in dogs. Additionally, the relatively high percentage of concurrent heart defects emphasizes the importance of accurate and complete examinations for identification. Because these data are from a cardiology referral center, a bias may exist.

Key words: Breed predisposition; Canine; Congenital heart defects; Multiple heart defects; Sex predisposition.

Cardiovascular malformations represent a substantial cause of morbidity and mortality in dogs <1 year of age.[1] The exact prevalence of these malformations is difficult to determine because some do not cause audible cardiac murmurs, some lead to perinatal death, and regional differences in breeds affect their frequency. In humans, cardiovascular malformations represent the most common congenital anomalies.[2] Early recognition is of great importance to achieve appropriate medical or surgical management, improve outcome and provide an accurate prognosis. For this purpose, the epidemiology of cardiovascular defects plays an important role. Several reports exist in veterinary literature regarding the prevalence of congenital heart disease (CHD) in dogs, mostly from the United States, Australia, United Kingdom, Sweden, and Switzerland.[1,3–6] The most commonly reported defects in this species are patent ductus arteriosus (PDA), pulmonic (PS) and subaortic stenosis (SAS), ventricular septal defects (VSD), tricuspid dysplasia, and tetralogy of Fallot (TOF).[1,4,5] The aim of this study was to review the incidence of congenital heart defects in a large population of dogs in Italy.

Abbreviations:

AS	valvular aortic stenosis
ASD	atrial septal defect
CHD	congenital heart disease
PDA	patent ductus arteriosus
PS	pulmonic stenosis
SAS	subaortic stenosis
TOF	tetralogy of Fallot
TTE	transthoracic echocardiography
VSD	ventricular septal defect

Materials and Methods

The medical records of 4,480 dogs presented for cardiovascular examination at Clinica Veterinaria Gran Sasso between 1997 and 2010 were reviewed retrospectively. Cases that presented with congenital heart defects were identified, and information regarding signalment, history, clinical examination, radiography, electrocardiography, echocardiography, angiography, and postmortem examination was obtained.

A complete transthoracic echocardiographic examination (TTE) was performed in all patients. Echocardiographic examinations were performed with an Esaote Caris ultrasound machine with mechanical transducers ranging from 2 to 10 MHz,[a] or Esaote Megas, Esaote Mylab30Vet, Esaote MyLab60 ultrasound machines with electronic transducers also ranging from 2 to 10 MHz.[a] The exams were performed and interpreted by the authors and reviewed by an ECVIM board-certified cardiologist (C.B., O.D., or both). The patients were placed in right and left lateral recumbency and the examinations were performed according to the American Society of Echocardiography standards and guidelines and other published recommendations.[7] Angiographic procedures also were performed by the authors with a fluoroscopy system[b] in cases undergoing interventional percutaneous procedures or when necessary for diagnostic purposes. Postmortem examinations were performed under the supervision of C.B., O.D., or both.

SAS lesions were classified according to the Pyle & Patterson studies as type 1, when presenting with a thickened and raised septal endocardium to form small nodules; type 2, when presenting with a fibrous thickening and raising of the subaortic endocardium forming a complete, or incomplete, fibrous ring below the aortic valve; and type 3, when presenting with a concentrical ''tunnel-like'' lesion at the left ventricular outflow tract.[8]

From the Department of Cardiology of Clinica Veterinaria Gran Sasso, Milano, Italia. *The results from this study have been partially presented as an abstract at the 20th ECVIM Meeting 2010 in Toulouse, France.*

Corresponding author: Pedro Oliveira, DVM, Clinica Veterinaria Gran Sasso, Via Donatello 26, 20131 Milano, Italia; e-mail: pedro mpdo@gmail.com.

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PS lesions were classified as type A when presenting with pulmonic leaflet thickening and fusion, and type B when presenting with pulmonic ostium hypoplasia with varying degrees of leaflet thickening and fusion.[8]

Statistical Analysis

Descriptive statistics were performed. The Kolmogorov-Smirnov test was used to assess normality. The Mann-Whitney test was used to identify differences in breed distribution between the CHD group and a reference population composed of 7,780 dogs of the same age range presented to Clinica Veterinaria Gran Sasso during the same time period. Breed and sex predilections were assessed by means of calculation of the relative risk with the odds ratio test. Breed predilection was considered to be present if a statistically significant ($P < .05$) odds ratio > 1.5 was observed with the following classification: mild increased risk if $1.5 < OR < 2.9$, moderate risk if $3.0 < OR < 4.9$, and marked risk if $OR > 5.0$. Only breeds represented by a minimum of 4 dogs were tested, except in the case of tricuspid dysplasia, in which this limit was set to 3 due the lower number of cases. Data processing and statistics were performed by commercially available statistics software[c] and Microsoft Excel 2003.[d]

Results

CHD was diagnosed in 976 (21.7%) of the 4,480 dogs. Single defects were present in 832 cases (85%), 2 concurrent defects in 132 cases (14%), and 3 concurrent defects in 12 cases (1%), corresponding to a total of 1,132 heart defects. Observed congenital heart defects are presented in Table 1, including information regarding sex and age at presentation. The most common were PS (32.1%), SAS (21.3%), and PDA (20.9%), followed by VSD (7.5%), valvular aortic stenosis (AS) (5.7%), and tricuspid dysplasia (3.1%). Angiographic procedures were performed in 158 cases: 116 PS, 1 AS, 28 PDA, 1 VSD, 3 PS with anomalous right coronary artery, 1 PS with anomalous right coronary artery and SAS, 3 PS with persistent left cranial vena cava, 2 atrial septal defects (ASD), 1 reverse PDA, 1 anomalous subclavian artery, 1 anomalous pulmonary venous return. Postmortem examinations were performed in 43 dogs: 4 PDA, 7 type 1 SAS, 4 type 2 SAS, 3 type 3 SAS, 6 type A PS, 8 type B PS, 3 muscular VSD, 4 perimembranous VSD, 2 TOF, 1 case with 2 stenotic pulmonic arteries, 1 aortic-pulmonary window.

Seventy-seven breeds were represented, with Boxer (26%) and German Shepherd (10%) being the most common, followed by mixed breed dogs (9.9%), English Bulldog (3.7%), and Newfoundland (3.7%). A statistically significant difference between breed distribution in the CHD group and the overall population was observed ($P < .0001$). Purebred dogs showed a significantly higher probability of presenting with CHD when compared with Mongrel dogs (OR, 3.3). Additionally, a mild increased risk for CHD was observed for 7 breeds: Chihuahua (OR, 2.5), English Bulldog (OR, 2.4), Labrador Retriever (OR, 2.3), Italian Mastiff (OR, 2.1), and German Shepherd, Golden Retriever, and West Highland White Terrier, all with OR of 1.8. A moderate risk was observed for 3 breeds: Boxer (OR, 4.6), American Staffordshire Terrier (OR, 4.2), and Newfoundland (OR, 3.6). Finally, a marked risk was observed for 4 breeds: Weimaraner (OR, 9.4), French Bulldog (OR, 8.2), Standard Schnauzer (OR, 7.1), and Australian Shepherd (OR, 5.6). Breed distribution and predispositions for the most commonly observed defects are presented in Tables 2–7. Sex distribution was similar to that of the overall population with males being slightly more frequent (54%) than females (46%). Specific male predisposition was observed for PS (OR, 1.5), SAS (OR, 1.7), and AS (OR, 2.6) and female predisposition for PDA (OR, 2.7). Mean age at presentation was approximately 42 months, ranging from 1 to 187 months.

Lesion classification information was available in 333 cases of PS. Type A was most common (n = 235, 70.6%), followed by type B (n = 84, 25.2%), mixed (n = 13, 3.9%), and supravalvular stenosis (n = 1, 0.3%).[9–11] In the case of SAS, lesion classification according to Pyle & Patterson[8,12,13] was available in 134 cases, with type 2 being the most common (n = 69, 51%), followed by type 3 (n = 41, 31%), and type 1 (n = 24, 18%).

Reverse PDA was observed in 6 of the 237 dogs with this defect. Diagnosis was made with the aid of agitated saline echocardiographic contrast in 5 cases and angiography in 1 case.

Multiple Heart Defects

The various combinations of congenital heart defects observed are presented in Table 8. The most commonly observed were PS and SAS (n = 38, 26.4%), followed by PS and VSD (n = 24, 16.7%). PDA was associated with a concurrent defect in 9.3% (n = 22) of the cases, mostly PS (n = 10, 45%) and SAS (n = 7, 32%). VSD was associated to another defect in 48% of the cases, mostly PS (65%).

Discussion

PS, SAS, PDA, and VSD consistently have been reported as being the most commonly encountered cardiac defects in previous studies.[1,4,5,14] In the present study, PS was the most common cardiac defect, accounting for 32.1% in contrast to 18–23% reported in other studies.[1,4,5,14] This difference may be because of the fact that our center receives many referrals for pulmonary balloon valvuloplasty. The high percentage of Boxers in our study (26%), and corresponding predisposition for PS (OR, 5.7), also may account for this fact. Boxer predilection for PS has already been reported in the literature,[13,15] as well as a male predisposition in this breed.[15] In the present study, male predisposition was observed in the overall breed population (OR, 1.5). Additionally, other breed predilections were identified, some of which had already been reported previously, as is the case of the English Bulldog, West Highland White Terrier, and Chihuahua.[1] Lack of predisposition of Golden Retriever, Labrador Retriever, and Yorkshire Terrier also is in accordance with previously published results.[1] According to our results, type A is the most common form observed, representing 70.6% of the cases in this study, as compared with 25.2% with type B. Mixed lesions (type A and B) seem to be uncommon

Table 1. Congenital heart defects.

Heart Defect	N	Isolated	Associated	Male	Female	Age (Months)[a]
Pulmonic stenosis	363 (32.1%)	271 (75%)	92 (25%)	216 (60%)[b]	145 (40%)[b]	40 (1–161)
Subaortic stenosis	241 (21.3%)	195 (81%)	46 (19%)	150 (62%)	91 (38%)	52 (1–187)
Patent ductus arteriosus	237 (20.9%)	215 (90.7%)	22 (9.3%)	83 (35%)	153 (65%)	38 (2–155)
Ventricular septal defect	85 (7.5%)	45 (52%)	40 (48%)	39 (46%)	46 (54%)	40 (3–157)
Aortic stenosis	64 (5.7%)	52 (81%)	12 (19%)	45 (70%)	19 (30%)	78 (4–158)
Tricuspid dysplasia	35 (3.1%)	26 (74%)	9 (26%)	17 (48.5%)	18 (51.5%)	41 (2–124)
Mitral dysplasia	21 (1.9%)	13 (62%)	9 (38%)	10 (48%)	11 (52%)	21 (4–94)
Double chamber right ventricle	14 (1.2%)	9 (64%)	5 (36%)	6 (43%)	8 (57%)	24 (4–69)
Atrial septal defect	12 (1.1%)	8 (67%)	4 (33%)	3 (27%)	8 (73%)	47 (10–128)
Tetralogy of Fallot	11 (1.0%)	—	—	6 (55%)	5 (45%)	14 (1–33)
Aortic hypoplasia	9 (0.8%)	0 (0%)	9 (100%)	5 (56%)	4 (44%)	51 (29–103)
Anomalous right coronary artery	9 (0.8%)	2 (22%)	7 (78%)	7 (78%)	2 (22%)	38 (17–66)
Persistent left cranial vena cava	9 (0.8%)	0 (0%)	9 (100%)	6 (67%)	3 (33%)	18 (44–110)
Cor triatriatum dexter	3 (0.3%)	3 (100%)	0 (0%)	1 (33%)	2 (67%)	37 (10–60)
4th right aortic arch	3 (0.3%)	2 (67%)	1 (33%)	2 (67%)	1 (33%)	10 (2–19)
Peritoneal-pericardial diaphragmatic hernia	3 (0.3%)	2 (67%)	1 (33%)	0 (0%)	3 (100%)	49 (7–84)
Patent foramen ovale	2 (0.2%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)	[c]
Situs inversus	2 (0.2%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)	62 (28–95)
Supravalvular aortic stenosis	1 (0.1%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)	3,6
Anomalous pulmonary venous return	1 (0.1%)	1 (100%)	0 (0%)	1 (100%)	0 (0%)	42
Truncus arteriosus	1 (0.1%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)	[c]
Aortic-pulmonary window	1 (0.1%)	1 (100%)	0 (0%)	1 (100%)	0 (0%)	45
Bicuspid aorta	1 (0.1%)	0 (0%)	1 (100%)	1 (100%)	0 (0%)	65
Quadricuspid aorta	1 (0.1%)	0 (0%)	1 (100%)	0 (0%)	1 (100%)	49
Anomalous subclavian artery	1 (0.1%)	0 (0%)	1 (100%)	0 (0%)	1 (100%)	113
Two stenotic pulmonary arteries	1 (0.1%)	0 (0%)	1 (100%)	0 (0%)	1 (100%)	24
Pericardial cyst	1 (0.1%)	0 (0%)	1 (100%)	1 (100%)	0 (0%)	31
Total	1132 (100%)					42 (1–187)

[a]Age at presentation.
[b]Information relative to sex was unavailable in 2 cases.
[c]Unavailable.

Table 2. Breed distribution and predisposition—pulmonic stenosis.

	Pulmonic Stenosis (363 cases)			
	N	%	Odds Ratio	*P*
Boxer	116	31.9	5.27	< .0001
Mongrel	35	9.6	0.32	< .0001
English Bulldog	27	7.4	3.16	< .0001
French Bulldog	21	5.8	19.1	< .0001
Pinscher	14	3.8	3.1	.0001
German Shepherd	11	3.0	0.44	.0085
Beagle	10	2.7	2.66	.003
West Highland White Terrier	9	2.5	2.91	.003
American Staffordshire Terrier	8	2.2	16.9	< .0001
Chihuahua	8	2.2	3.11	.003
Cavalier King Charles Spaniel	6	1.6	1.62	NS
Cocker Spaniel	6	1.6	1.1	NS
Pitbull Terrier	6	1.6	4.48	.0009
Rottweiler	6	1.6	0.91	NS
Newfoundland	5	1.4	0.81	NS
Golden Retriever	5	1.4	0.97	NS
Shih-Tzu	5	1.4	0.78	NS
Yorkshire Terrier	5	1.4	0.23	.0013
Italian Mastiff	4	1.1	2.1	NS
Poodle	4	1.1	0.23	.0062
Standard Schnautzer	4	1.1	16.7	< .0001
Others	48	13.2		

(3.9%) and supravalvular stenosis is a rare occurrence (0.3%). The presence of an associated anomalous right coronary artery was suspected in 8 cases by TTE, and confirmed by angiography in 4 cases and by TEE in 1 case. Angiographic classification was available in only 3 cases, all presenting with type R2A anomaly.[16] Half of these dogs were English Bulldogs, a fact that is in agreement with previous reports of predisposition for this breed.[17,18]

The 2nd most commonly observed CHD in this study was SAS (21.3%), similar to what has been reported

Table 3. Breed distribution and predisposition—subaortic stenosis.

	Subaortic Stenosis (241 Cases)			
Breed	N	%	Odds Ratio	*P*
Boxer	121	49.8	9.4	< .0001
German Shepherd	24	9.9	1.8	.0166
Dogue de Bordeaux	18	7.4	11.2	< .0001
Newfoundland	23	9.5	7.0	< .0001
Rottweiler	16	6.6	4.5	< .0001
Golden Retriever	13	5.3	3.6	.0001
Mongrel	5	2.1	0.1	< .0001
Labrador Retriever	4	1.6	0.6	NS
Others	18	7.4		

Table 4. Breed distribution and predisposition—valvular aortic stenosis.

	Aortic Stenosis (64 Cases)			
Breed	N	%	Odds Ratio	*P*
Boxer	40	62.5	17.9	< .0001
Bull Terrier	5	7.8	41	< .0001
German Shepherd	5	7.8	1.14	NS
Others	14	21.9		

previously in the United States,[1,14] but in contrast to other European studies in which it was the most common cardiac defect, accounting for 31.5[5] and 35%[4] of all cardiac defects. In this study, subvalvular and valvular lesions were considered separately, with aortic valvular stenosis accounting for an additional 5.7% of the cases, and comparison between study results should take this fact into account. Nevertheless, combined SAS and AS still account for the 2nd most common congenital pathology with an incidence of 27%. Males seem to be predisposed (OR, 1.7) in contrast to previous reports in which sex predilection had not been confirmed,[1] except in the Boxer breed.[1,15] This breed represented, however, almost half (49.8%) of the cases of SAS in the present study and influenced the results. Data were reanalyzed excluding this breed and, although males were still more prevalent than females (63 versus 37%), a statistically significant higher relative risk for males was not confirmed (OR, 1.1; $P = .7$). Breed predilections observed for SAS, except for Dogue de Bordeaux (OR, 11.2), had already been described and are in agreement with a previous study.[1]

Regarding PDA, its prevalence in the United States seems to be higher[1,14] than in Europe.[4,5] In the present study, it was the 3rd most common defect (20.9%), slightly more prevalent than in previous European reports (4th most common, 11–13.7%)[4,5] and less common than in USA reports (most common, 27.7–32%).[1,14] Similar to PS, many PDA cases received by our center are

Table 5. Breed distribution and predisposition—patent ductus arteriosus (PDA).

	PDA (237 Cases)			
Breed	N	%	Odds Ratio	*P*
German Shepherd	58	24.5	5.2	< .0001
Mongrel	41	17.3	0.65	.018
Newfoundland	13	5.5	4.65	< .0001
Maltese	12	5.1	4.14	< .0001
Dobermann	12	5.1	2.8	.0007
Poodle	12	5.1	1.18	NS
Yorkshire Terrier	9	3.8	0.71	NS
Cavalier King Charles Spaniel	9	3.8	3.7	.0006
Dachshund	6	2.5	0.42	.0372
Chihuahua	6	2.5	3.66	.0028
West Highland White Terrier	4	1.7	1.93	NS
Pomeranian	5	2.1	2.5	NS
Irish Setter	5	2.1	0.94	NS
Belgian Shepherd	4	1.7	4.38	.0059
Australian Shepherd	4	1.7	27.3	< .0001
Others	37	15.6		

Table 6. Breed distribution and predisposition—ventricular septal defect (VSD).

	VSD (85 Cases)			
Breed	N	%	Odds Ratio	*P*
Mongrel	13	15.3	0.6	NS
Pinscher	5	5.9	39	< .0001
French Bulldog	4	4.7	7.2	.0003
German Shepherd	4	4.7	3.7	.001
Labrador Retriever	4	4.7	0.8	NS
Others	55	64.7		

referred for surgical ligation or transcatheter embolization, therefore increasing its apparent incidence in comparison with what would be expected in a first opinion practice center. For the same reason, the observed incidence of reverse PDA probably is an underestimate of the real incidence, because this condition is not suitable for occlusion. Females are consistently reported as being more often affected than males,[1,4,19–21] and the results of our study support this predilection, indicating a female predisposition for PDA (OR, 2.7). Considering breed incidence and predilections, the results of this study are slightly different from those of other reports. The German Shepherd was the most commonly affected breed and a markedly higher risk was observed (OR, 5.2), in contrast to previously published results in which a higher risk was not identified (nonsignificant odds ratio of 1.2), although this breed was among the most common breeds with PDA.[1] Furthermore, Poodle, Pomeranian, and Yorkshire Terrier predisposition reported by the same study[1] was not confirmed in the present study. This might be because of differences in breed popularity and incidence between the 2 geographic areas. The same applies to Chihuahua and Australian Shepherd for which a statistically significant higher risk was observed in this study in contrast to the other study.[1] In both studies, the Maltese breed was found to be at a markedly higher risk for PDA.

VSD was the 4th most common cardiac defect in our study, with a lower incidence (7.5%) than reported previously (9.8–14.4%).[1,4,5] Interestingly, VSD was observed in conjunction with another cardiac defect in almost half of the cases (48%) and usually with PS (65%). This association was observed in 23 dogs, of which 19 were presented with a type A PS and a perimembranous VSD (n = 9) or a muscular VSD (n = 8).

Table 7. Breed distribution and predisposition—tricuspid dysplasia.

	Tricuspid Dysplasia (35 Cases)			
Breed	N	%	Odds Ratio	*P*
Labrador Retriever	9	25.7	11.13	< .0001
Boxer	5	14.3	1.96	NS
German Shepherd	5	14.3	2.24	NS
English Bulldog	3	8.6	6	.0035
Golden Retriever	3	8.6	6.6	.0022
Others	10	28.5		

Table 8. Multiple heart defects.

Associated Pathologies	N
PS + SAS	34
PS + VSD	19
PS + PDA	8
PDA + SAS	6
SAS + Mitral dysplasia	5
SAS + Perimembranous VSD	4
PS + Anomalous right coronary artery	4
SAS + Aortic stenosis	3
SAS + Aortic root hypoplasia	3
PS + 2 Muscular VSD	3
PS + AS	3
PS + Persistent left cranial vena cava	3
PS + Tricuspid dysplasia	3
AS + Aortic root hypoplasia	2
SAS + Situs inversus	2
VSD + Double chambered right ventricle	2
VSD + Mitral dysplasia	2
PS + AS + Aortic hypoplasia	2
PS + Persistent left cranial vena cava + Anomalous right coronary artery	2
AS + Bicuspid aorta	1
PDA + 4th right aortic arch	1
PDA + Anomalous Subclavian	1
PDA + AS	1
PDA + Mitral dysplasia	1
PDA + Tricuspid dysplasia	1
PDA + VSD	1
SAS + Muscular VSD	1
SAS + Persistent left cranial vena cava	1
SAS + Persistent left cranial vena cava + VSD	1
SAS + Persistent left cranial vena cava + mitral stenosis	1
SAS + Bicuspid aorta	1
SAS + Quadricuspid aorta	1
SAS + Tricuspid dysplasia	1
SAS + Double chambered right ventricle + Mitral stenosis	1
SAS + Aortic root hypoplasia + Supravalvular stenosis	1
Tricuspid dysplasia + Patent foramen ovale	1
Tricuspid dysplasia + ASD	1
Tricuspid dysplasia + Cor triatriatum dexter	1
Tricuspida dysplasia + Double chambered right ventricle	1
VSD + ASD	1
VSD + ASD like Sinus Venosus Coronaricus	1
VSD + Persistent left cranial vena cava	1
PS with 2 stenotic pulmonary arteries	1
PS + ASD	1
PS + Double chambered right ventricle	1
PS + PDA + Peritoneal-pericardial-diaphragmatic hernia	1
PS + Pericardial cyst	1
PS + Patent foramen ovale	1
PS + SAS + PDA	1
PS + SAS + Anomalous right coronary artery	1
PS + SAS + Aortic hypoplasia	1
PS + SAS + VSD	1
PS + VSD + Anomalous coronary trunk	1

AS, valvular aortic stenosis; ASD, atrial septal defect; PDA, patent ductus arteriosus; PS, pulmonic stenosis; SAS, subaortic stenosis; VSD, ventricular septal defect.

Only 4 cases were presented with a type B PS, 3 with a perimembranous VSD and 1 with a muscular VSD. In humans, VSD may coexist with nearly all varieties of CHD[22] and often is associated with ASD, PDA, PS, and right aortic arch.[23] Additionally, a possible association between PS and VSD has been suggested because their incidence was found to be more common than would be expected by chance.[24] A possible relationship between these defects and TOF also has been proposed but not proven.[24] If the pulmonary valve gradient is high enough, right ventricular hypertrophy, another characteristic of TOF, may occur. This was observed in most of the cases in the present study, however, without aortic overriding, and therefore not true TOF. Evidence of conotruncal development abnormality must be present in the case of TOF. No differences were identified in breed or sex incidence between these subpopulations and the overall population of dogs with PS. Pinscher, French Bulldog, and German Shepherd seem to be at higher risk. Other breed predilections have been described elsewhere.[1]

The incidence of tricuspid dysplasia (3.1%) also was slightly lower than reported previously (5.1–7.5%).[1,4,5] With the exception of English Bulldog, the predilections observed in the case of Labrador Retriever and Golden Retriever had already been previously reported and are in agreement.[1] A previously observed higher female incidence was not confirmed in the present study.[4]

ASD represented 1.1% of cardiac defects, a result in agreement with most previously published reports[1,4,25] but much lower than in 1 other study.[26] Additionally, no breed predilection was observed in contrast to other previous reports in which Boxers were at higher risk.[1,26] The diagnosis of ASD was achieved by echocardiographic examination, as in the case of the studies mentioned above.[4,26] In the past, it has been shown that the risk of overlooking cardiac defects with echocardiography was greater than the risk of overdiagnosing them.[27] This report, however, relied on the use of 2-dimensional echocardiographic imaging, and since it has been published, substantial advances have been made in echocardiographic imaging that in combination with Doppler technology have rendered this diagnostic method much more sensible and reliable.[26] Additionally, all echocardiographic examinations in this study were performed by experienced operators with a combination of 2D and Doppler techniques, and therefore, in our opinion, ASD were not underdiagnosed. TOF and persistent right aortic arch were less frequent in the present study than reported previously.[1]

In previous reports, the incidence of multiple heart defects was 7–8%,[4,5] approximately half that of the present study (15%). From the analysis of the results of this and other studies, the association between PS and SAS seems to be one of the most common associations between heart defects in dogs.[4,15] The frequent association between VSD and other defects, and the presence of concurrent PS and PDA in some dogs, emphasizes the importance of performing a complete echocardiographic examination in all dogs, even when an anomaly possibly explaining the clinical findings has already been identified.

Considering the breed predispositions observed in this study, we believe that it is prudent to advise systematic screening for congenital cardiac defects before breeding,

in order to decrease their prevalence, especially in breeds demonstrating a moderate or increased risk for these defects. Such is the case in the Boxer, Newfoundland, French Bulldog, English Bulldog, German Shepherd, Golden Retriever, and Labrador Retriever, all of which demonstrated an increased risk for cardiac defects in general, and for some defects in particular. Although other breeds appear to be at increased risk according to the results of this study, we believe that because of their lower incidence in the general population (<1%), caution must be taken when interpreting the results and further studies are necessary. Nevertheless, owners and breeders of these breeds should be appropriately informed of this fact, and clinicians should have a high index of suspicion when examining individuals of these breeds, and promptly inform breeders of the existence of cardiac defects.

From an analysis of Table 1, it can be seen that the average age at the time of diagnosis was >2 years for most defects. These results are influenced by late diagnosis in some mild cases. Nevertheless, ideally we would expect these defects to be identified at a much earlier age in order to be able to optimize therapeutic management and maximize life expectancy and quality of life. A greater awareness of clinicians, owners, and breeders to the existence of these defects is necessary in order to improve medical care for these patients.

In conclusion, this study allowed us to characterize the incidence of CHD in a large population of dogs in Italy, and only minor differences were observed in comparison with previous studies from other geographical areas.[1,4,5,14] The retrospective nature, as well as the fact that the data derives from a cardiology referral center, constitute limitations to the design of our study. Particularly, defects amenable to surgical or percutaneous repair, such as PS, SAS, and PDA, may be overrepresented in this study. Breed and sex predilections were identified for some defects, confirming or adding to previously observed tendencies, and may be of value for the diagnosis and screening of CHD in dogs. Finally, concurrent heart defects represented a substantial percentage of cases, and their identification depends upon accurate and complete examinations.

Footnotes

[a] ESAOTE S.p.A., Firenze, Italy
[b] Villa Sistemi Medicali S.p.A., Buccinasco (MI), Italy
[c] MedCalc 10.2.0.0, Mariakerke, Belgium
[d] Microsoft Office Excel 2007, Microsoft Corp, Redmond, WA

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