PULSED-WAVE DOPPLER ECHOCARDIOGRAPHY IN BIRDS OF PREY: A USEFUL TECHNIQUE?

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SUMMARY

The aim of this study was to determine if pulsed wave spectral Doppler echocardiography is possible to effectively perform in birds of prey and if limiting factors may be controlled by patient preparation, restraint and handling. For this purpose, 146 diurnal and nocturnal raptors of both sexes with body mass ranging from 190 to 4200g were examined. In the first stage, 40 birds were examined without special preparation. Secondly in 15 raptors echocardiography was performed once without anaesthesia and then once with anaeasthesia. In a further group of 41 birds, patients were fasted for different periods of time. Finally 15 birds in which echocardiography was not possible using standard (dorsal) restraint and positioning, birds were repositioned in lateral as well as ventral recumbency. Within the group of birds with a body mass of 190 to 2300g independent of body mass, heart rate, anaesthesia, and fasting dopler derived diastolic inflow into the ventricles was detectable in approximately 80 %. In about 50 % of these birds, aortic blood flow was also detected. Doppler echocardiography performed under standard conditions (dorsal recumbency) was not possible (with the exception of one bird) in raptors with body masses higher than 3000g and in about 20 % of the raptors aforementioned. In 11 of 15 birds in which Doppler echocardiography was not performable under standard conditions Doppler derived detection of blood flow within the ventricles and/or within the aorta became possible after repositioning of the patients. Systolic blood flow via the pulmonary artery was not detectable in any bird.

Introduction

Birds of prey are frequently presented to veterinarians for different reasons. On occasions wild birds are presented to veterinary facilities following trauma or other problems, which impairs their flight capability. In these birds during the treatment of the apparent injury (which often takes several days to weeks and which is often combined with a partly or completely immobilisation of the patient) the assessment of the prognosis for rehabilitation is of particular importance. To date, little is known about the influence of immobility or pre release training, respectively on the efficiency of the cardiovascular system in birds. Doppler echocardiography might be a useful tool to gain further knowledge on this topic. On the other hand, side raptors which are kept in captivity for different reasons (e. g. exhibition and hunting) are routinely presented to veterinary practices or clinics. Several of these birds are suspected to suffer from cardio-vascular problems. For the confirmation or exclusion of this suspicion a complete examination of the card-vascular system is necessary. Unfortunately, to date in avian cardiology little work has been done on the establishment of examination techniques, which are routinely performed in human and small animal cardiology. Echocardiography for example a method which provides different techniques (above all B-mode, M-mode, and different Doppler techniques) is very rarely performed in avian patients although this method is one of the most important imaging techniques in human and small animal cardiology. So far, only one study concerning B-mode echocardiography in raptors has been published (Boskovic et al. 1999). Unfortunately, B-mode technique mainly provides information about morphological aspects of the heart but not about the blood flow and therefore it is not useful for the assessment of the haemodynamic status. The aim of this study was to scrutinise if pulsed wave spectral Doppler technique can be performed in birds of prey and if any limitations of the technique can be minimalised.

MATERIAL AND METHODS

Standard methods used in all birds

For this study, a total of 146 diurnal and nocturnal raptors of both sexes with a body mass of 190 to 4200 grams were examined. Prior to echocardiographical examination each bird had a physical and if indicated radiological examination in particular of the card vascular system. None of the birds showed any signs of cardio-vascular abnormalities. Following physical examination, each bird's heart was examined by means of sonography (Sonoace 8800, Kretz-Technik, Wiesbaden, Germany) as described by Boskovic et al. (1999). Initially B-mode echocardiography was performed. Standard water-soluble coupling gel was used and the scanner (micro-curved-array, 7.5 MHz) was placed in the ventro-median approach directly caudally to the sternum. By placing, the scanner in a vertical orientation with the ultrasound beam directed cranially followed by a contra clockwise rotation the two- and the four-chamber view were focused. The results obtained from B-mode technique (especially the ratio of the left to the right ventricle chamber size) were compared to published data. None of the hearts showed any deviation from the values established by Boskovic et al (1999) which might indicate a morphological abnormality of the heart. The quality of all B-mode images was assessed applying the criteria listed in Table 1. Following the B-mode echocardiographical examination, all birds under went pulsed-wave spectral Doppler examination of the diastolic in flow into the left and the right ventricle as well as the systolic outflow (aorta and arteria pulmonalis) were performed or at least attempted.

The first 40 birds examined (Table 2) had were presented with minor clinical problems (treatment of small wounds, feather loss, beak trimming) and were examined ultrasonographically without any special preparation. Following these examinations and the evaluation of the results the question arose whether the quality of the B-mode image as well as the ability to perform spectral Doppler examinations could be influenced by special patient preparation. As all the birds examined so far had been private birds visiting the premises of one author (NAF) it was not possible to repeat these tests on the same birds. For this reason further birds were examined which were provided from other private breeders and raptor centres.

Further procedures

Following the examinations described above a further 15 birds (Table 3) which were under going anaesthesia for other reasons were examined once prior to induction and again during isoflorane inhalation anaesthesia. Anaesthesia was induced via mask (5% isoflurane in oxygen) and maintained following entubation (2-3 % isoflurane in 1L/min oxygen). One problem which was considered might have contributed to the technical difficulties in the initial group of birds was the potential for physiologically normal dietary bones within the proventriculus to interfere with the echoustic window required for effective ultrasonography. The initial group of birds had been fasted for varying intervals (Table 4). Further more with experience gained from avian endoscopy the authors were aware that the position of internal organs and their respective effect on air sac size could by influenced by repositioning of the patient. From a subsequent group of 50 raptors, 15 birds for whom ultrasonography in dorsal recumbency was ineffective, were chosen and placed in left lateral as well as ventral recumbency for echocardiographical examination (Figure 1 and Table 5).

RESULTS

Birds without special preparation

B-mode echocardiography to a quality which at least enabled the positioning of the Doppler gate (quality level 1 and higher, see Table 1) was obtained from 27 (quality level 1=14 birds, quality level 2=12 birds, quality level 3=one bird) of the 40 birds (67,5 %) which were examined without special preparation (Table 2). In birds with a body mass from 190 to 2300g (N=31) the positioning of the Doppler gate was possible in 26 cases (83,9 %). In 8 of 9 raptors (88,9 %) with a body mass of 3400 to 4200 g due to bad B-mode image quality (Quality level 0) spectral Doppler examination was not performable. In the first group of birds (body mass 190 to 2300 g) neither an interdependence of the body mass and the possibility of the positioning of the Doppler gate nor of the heart frequency and the capability of the Doppler gate positioning were evident. Doppler derived diastolic inflow into the left and the right ventricle was detectable in all birds, which provided B-mode images with at least the quality level 1. Doppler derived aortic outflow was detectable in 14 of these birds (= 51,9 %) (Figure 2). Systolic blood flow via the pulmonary artery was not detectable in any bird.

Anaesthetised birds

During examination without anaesthesia in 12 of 15 birds (80,0 %) B-mode images which enabled the positioning of the Doppler gate were obtained (Table 3). As in the birds without special preparation (with the exception of one bird in which the inflow into the left ventricle was not detectable), in all of these birds Doppler derived velocity of the diastolic inflow into the left and the right ventricle was detectable. Systolic aortic outflow was detectable in 6 of these birds (50,0 %). Under anaesthesia once again in 12 of the 15 raptors B-mode images with a quality of at least level 1 were obtained. Diastolic inflow into the left and the right ventricle was detectable in all cases. Doppler-derived velocity of the aorta was detectable in 7 birds (58,3 %). In none of the birds which provided very bad B-mode images without anaesthesia the positioning of the Doppler gate was possible under anaesthesia. In 9 raptors which provided moderate to good B-mode images the quality level of the images did not change, in three birds the quality slightly increased, and in three birds the quality slightly decreased without any effect on the capability of performing spectral Doppler echocardiography. The detection of blood flow via the pulmonary artery was neither possible under nor without anaesthesia. Consequently, significant differences concerning the practicability of spectral Doppler examination in anaesthetised and not anaesthetised raptors could not be shown.

Fasted birds

In 12 of 14 birds (85,7 %) which were fed less than eight hours prior to echocardiographical examination Doppler derived detection of the diastolic ventricular inflow was detectable (Table 4). In two birds, B-mode images which did not allow the positioning of the Doppler gate were obtained. Aortic blood flow was detectable in 6 birds (50 % of the birds in which Doppler echocardiography was possible). Within the group of raptors which fastened 18 to 24 hours prior to examination also in two birds B-mode image quality was of level 0. Thus in 11 of 13 (84,6 %) birds spectral Doppler echocardiography at least of the left side ventricular inflow was performable. In one of these birds, diastolic inflow into the right ventricle was not detectable. Aortic blood flow was detected in five of 11 raptors (45,5 %). In three of 14 birds which had not eaten for >36 hours prior to examination spectral Doppler examination was not performable. Thus in 78,6 % of the birds of this group at least Doppler derived detection of ventricular inflow into the left ventricle was detectable. Ventricular inflow into the right ventricle was detectable in ten birds. Systolic aortic outflow could be shown in seven raptors (63,6 % of the birds of this group in which Doppler echocardiography was performable). Finally, it can be concluded that no significant differences between the groups could be proved. As in the birds without special preparation, an interdependence of the body mass and the possibility of the positioning of the Doppler gate were not evident. Furthermore, as in all other birds blood flow within the pulmonary artery was not detectable.

Birds which were positioned in different recumbencies

In 11 of 15 raptors (73,3 %) which provided very bad B-mode images (which did not allow the positioning of the Doppler gate) in dorsal recumbency by repositioning of the bird in lateral and / or ventral recumbency the quality of the B-mode image increased at least to the extent that the positioning of the Doppler gate became possible. Lateral positioning of the bird improved the B-mode image quality in seven birds, ventral positioning in 9 birds. In five birds both lateral as well as dorsal recumbency enabled the positioning of the Doppler gate. Thus none of the two recumbencies can be favoured but repositioning of raptors which provide very bad B-mode images in one position is recommended.

DISCUSSION

Echocardiography is one of the most important imaging techniques in human as well as in small animal cardiology. Consequently, the use of this technique should be a basic requirement for cardiological examinations in birds. Unfortunately, to date little to nothing is known about the practicability of different echocardiographical techniques in avian medicine. With the exception of some case reports about the use of Doppler echocardiography in psittacines and an ostrich suffering from cardio-vascular disease (Baptiste et al., 1997, Vink-Nooteboom et al. 1998, EVANS et al. 2001, Oglesbee and Lehmkuhl, 2001) nothing is published about this technique in birds.

In conducting this study the authors aims had been to discover if Doppler echocardiography is technically possible in raptors. Having performed Doppler echocardiography in the first 40 raptors it could be shown, however it also became evident that in a number of birds irrespective of heart rate but particularly in raptors with body >3000g the technique was of limited value. Having detected this limitation, it was then questioned whether any special preconditioning, anaesthesia or positioning could minimise these problems. Neither anaesthesia or fasting increased the value of the technique. The number of birds in which Doppler echocardiography was performable could be increased by changing the standard position for ultrasound examination in birds (dorsal recumbency) to lateral and ventral recumbency respectively.

Finally it can be stated that pulsed wave Doppler echocardiography in principle is performable in raptors with body masses from 190 to 4200 g. It could be shown that by special preparation of the patient Doppler echocardiography is performable even in birds which yielded very bad images in routinely performed dorsal recumbency. Repositioning of any patient in which echocardiography seems to be impossible must be recommended. Further examinations for the establishment of reference values are ongoing and will be published soon.

Acknowledgement
This study was funded by the DFG (Deutsche Forschungsgemeinschaft). The authors would like to thank Mr B Allis (The Barn Owl Centre) and Mrs J Parray-Jones MBE (The National Birds of Prey Centre) for making the birds available. Special thanks to Mark, Annie, Gary, Alasdair, Gareth, and Martin for their indefatigable help.

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Table 1: Criteria for the quality classification of the B-mode images

Quality of B-mode image	Criteria
0	Very bad image. Heart movement noticeable but no differentiation between the ventricles and/ or atria. Positioning of the Doppler-gate impossible.
1	Moderate image. Differentiation between the ventricles and positioning of the Doppler-gate possible. Subjective assessment of the relation of the sizes of the ventricles possible in moving but not in freezed images.
2	Good image. Measurement of the diameter of the ventricles possible in freezed images.
3	Very good image. Good detail identification (e. g. atrioventricular and aortic valves)

Table 2: Birds examined without special preparation

No	Species	Sex	BM [g]	HF [min^{-1}]	Q	LV	RV	Ao
1	*Otus lettia*	?	190	360	1	+	+	-
2	*Otus lettia*	?	200	300	1	+	+	+
3	*Falco columbarius*	f	200	480	2	+	+	-
4	*Tyto alba*	f	220	320	0	-	-	-
5	*Tyto alba*	f	340	180	3	+	+	+
6	*Ninox boobook*	?	340	270	1	+	+	+
7	*Tyto alba*	m	370	200	2	+	+	-
8	*Strix aluco*	m	410	180	2	+	+	+
9	*Strix aluco*	m	410	300	0	-	-	-
10	*Falco biarmicus*	m	450	210	1	+	+	+
11	*Falco biarmicus*	m	490	330	2	+	+	-
12	*Bubo megallanicus*	m	510	270	1	+	+	+
13	*Falco biarmicus*	m	610	240	2	+	+	+
14	*Parabuteo unicinctus*	m	650	300	0	-	-	-
15	*Bubo megallanicus*	f	675	330	2	+	+	+
16	*Parabuteo unicinctus*	m	740	450	1	+	+	-
17	*Parabuteo unicinctus*	m	740	300	1	+	+	+
18	*F rusticolus* x *F peregrinus*	m	795	240	2	+	+	-
19	*Falco peregrinus*	f	840	380	1	+	+	+
20	*Buteo buteo*	m	840	250	0	-	-	-
21	*Falco peregrinus*	f	900	270	1	+	+	+
22	*Falco cherrug*	f	900	270	2	+	+	-
23	*Falco cherrug*	m	910	300	1	+	+	-
24	*Strix leptogrammica*	f	930	210	2	+	+	+
25	*Milvus milvus*	f	950	240	2	+	+	+
26	*Parabuteo unicinctus*	f	1000	330	1	+	+	-
27	*Parabuteo unicinctus*	f	1050	300	0	-	-	-
28	*Parabuteo unicinctus*	f	1130	270	1	+	+	-
29	*Buteo jamaicensis*	f	1370	300	2	+	+	+
30	*Buteo regalis*	f	2100	270	1	+	+	-
31	*Bubo bubo*	m	2300	180	2	+	+	-
32	*Bubo virginianus*	f	3400	270	0	-	-	-
33	*Aquila chrysaetos*	m	3500	240	0	-	-	-
34	*Bubo bubo*	m	3500	210	0	-	-	-
35	*Bubo bubo*	f	3600	330	0	-	-	-
36	*Bubo bubo*	m	3800	180	0	-	-	-
37	*Aquila chrysaetos*	f	4000	200	0	-	-	-
38	*Aquila chrysaetos*	m	4080	330	1	+	+	-
39	*Aquila chrysaetos*	f	4100	190	0	-	-	-
40	*Aquila chrysaetos*	f	4200	250	0	-	-	-

No = number, m = male, f = female, BM = body mass, g = gram, HF = heart frequency, min = minute, Q = quality of B-mode image, LV = left-sided ventricular inflow, RV = right-sided ventricular inflow, Ao = aortic outflow, + = detectable by means of pulsed-wave Doppler echocardiography, - = not detectable by means of pulsed-wave Doppler echocardiography

Table 3: Birds examined once without and once under anaesthesia

No	Species	S	BM [g]	not anaesthetised					anaesthetised				
				HF [min^{-1}]	Q	LV	RV	Ao	HF [min^{-1}]	Q	LV	RV	Ao
1	*Buteo buteo*	m	850	420	0	-	-	-	240	0	-	-	-
2	*Buteo buteo*	m	700	390	2	+	+	+	210	2	+	+	+
3	*Buteo buteo*	m	900	390	0	-	-	-	270	0	-	-	-
4	*Buteo buteo*	f	1100	300	2	+	+	+	270	3	+	+	+
5	*Buteo buteo*	m	890	330	2	+	+	+	270	1	+	+	+
6	*Buteo buteo*	f	1050	390	2	+	+	-	240	1	+	+	-
7	*Buteo buteo*	f	990	330	1	+	+	-	240	2	+	+	+
8	*Buteo buteo*	f	1200	270	2	+	+	+	210	2	+	+	+
9	*Buteo buteo*	m	700	330	1	+	+	-	270	1	+	+	-
10	*Buteo buteo*	m	960	270	3	+	+	+	270	1	+	+	+
11	*Buteo regalis*	f	2100	270	1	+	+	-	270	1	+	+	-
12	*Parabuteo unicinctus*	f	1030	300	0	-	-	-	300	0	-	-	-
13	*Milvus milvus*	m	950	270	1	+	+	-	240	1	+	+	-
14	*Tyto alba*	f	350	180	2	-	+	+	270	2	+	+	+
15	*Parabuteo unicinctus*	f	1000	240	1	+	+	-	210	2	+	+	-

No = number, S = sex, m = male, f = female, BM = body mass, g = gram, HF = heart frequency, min = minute, Q = quality of B-mode image, LV = left-sided ventricular inflow, RV = right-sided ventricular inflow, Ao = aortic outflow, + = detectable by means of pulsed-wave Doppler echocardiography, - = not detectable by means of pulsed-wave Doppler echocardiography

Table 4: Birds examined different times after last feeding

No	Species	Sex	BM [g]	Fastened [h]	Q	LV	RV	Ao
1	*Tyto alba*	f	220	< 8	0	-	-	-
2	*Tyto alba*	f	340	< 8	2	+	+	+
3	*Tyto alba*	?	350	< 8	3	+	+	+
4	*Falco biarmicus*	m	490	< 8	2	+	+	-
5	*Falco peregrinus*	m	560	< 8	1	+	+	+
6	*Parabuteo unicinctus*	m	640	< 8	1	+	+	-
7	*Parabuteo unicinctus*	m	670	< 8	1	+	+	-
8	*Strix leptogrammica*	m	750	< 8	1	+	+	+
9	*Buteo buteo*	f	840	< 8	0	-	-	-
10	*Falco cherrug*	f	900	< 8	1	+	+	+
11	*Falco cherrug*	m	900	< 8	2	+	+	-
12	*Parabuteo unicinctus*	f	1030	< 8	1	+	+	-
13	*Parabuteo unicinctus*	f	1120	< 8	1	+	+	+
14	*Parabuteo unicinctus*	f	1190	< 8	1	+	+	-
15	*Otus lettia*	?	190	18 - 24	1	+	+	-
16	*Otus lettia*	?	200	18 - 24	1	+	-	-
17	*Ninox boobook*	?	340	18 - 24	1	+	+	+
18	*Tyto alba*	?	350	18 - 24	0	-	-	-
19	*Tyto alba*	?	360	18 - 24	2	+	+	+
20	*Falco biarmicus*	m	610	18 - 24	2	+	+	+
21	*Falco cherrug*	f	900	18 - 24	1	+	+	-
22	*Falco cherrug*	m	900	18 - 24	2	+	+	-
23	*Milvus milvus*	f	950	18 - 24	2	+	+	+
24	*Milvus milvus*	f	950	18 - 24	1	+	+	-
25	*Falco peregrinus*	f	1000	18 - 24	1	+	+	+
26	*Parabuteo unicinctus*	f	1060	18 - 24	1	+	+	-
27	*Geranoaetus melanoleucus*	m	1200	18 - 24	0	-	-	-
28	*Bubo megallanicus*	m	550	> 36	1	+	+	+
29	*Mivus migrans*	m	600	> 36	1	+	+	-
30	*Mivus migrans*	m	625	> 36	1	+	+	-
31	*Pulsatrix perspicillata*	m	650	> 36	1	+	-	-
32	*Strix leptogrammica*	f	650	> 36	0	-	-	-
33	*F peregrinus x F cherrug*	m	740	> 36	1	+	+	+
34	*Pulsatrix perspicillata*	f	750	> 36	2	+	+	+
35	*Falco mexicanus*	m	800	> 36	0	-	-	-
36	*Milvus milvus*	m	890	> 36	2	+	+	+
37	*Strix leptogrammica*	f	900	> 36	2	+	+	+
38	*Parabuteo unicinctus*	m	900	> 36	2	+	+	-
39	*Parabuteo unicinctus*	f	1060	> 36	1	+	+	+
40	*Nyctea scandiaca*	f	180	> 36	0	-	-	-

			0					
41	*Nyctea scandiaca*	m	140 0	> 36	2	+	+	+

No = number, m = male, f = female, BM = body mass, g = gram, h = hour(s), Q = quality of B-mode image, LV = left-sided ventricular inflow, RV = right-sided ventricular inflow, Ao = aortic outflow, + = detectable by means of pulsed-wave Doppler echocardiography, - = not detectable by means of pulsed-wave Doppler echocardiography

Table 5: B-mode image quality obtained from birds positioned in different recumbencies

No	Species	Sex	BM [g]	Q (d)	Q (l)	Q (v)
1	*Falco tinnunculus*	f	200	0	0	0
2	*Asio otus*	m	270	0	1	0
3	*Asio flammeus*	m	320	0	0	0
6	*Falco peregrinus*	m	560	0	0	0
8	*Strix leptogrammica*	m	680	0	1	1
11	*Melierax poliopterus*	f	800	0	1	0
13	*Buteo buteo*	m	840	0	1	1
18	*Nyctea scandiaca*	m	1300	0	0	0
19	*Bubo bubo*	m	2900	0	0	2
20	*Bubo bubo*	m	3400	0	0	1
21	*Aquila chrysaetos*	m	3600	0	1	1
22	*Bubo bubo*	f	3800	0	1	1
23	*Aquila chrysaetos*	f	4000	0	1	1
24	*Aquila chrysaetos*	m	4100	0	0	1
25	*Aquila chrysaetos*	f	4200	0	0	1

No = number, m = male, f = female, BM = body mass, g = gram, Q = quality of B-mode image in (d) dorsal recumbency, (l) lateral recumbency, and (v) ventral recumbency