Fallot's tetralogy in a European beaver (Cator fiber)

Wenger, S; Gull, J; Glaus, T M; Blumer, S; Wimmershoff, J; Kranjc, A; Steinmetz, H W; Hatt, J M


Postprint available at:
http://www.zora.uzh.ch

Posted at the Zurich Open Repository and Archive, University of Zurich.
http://www.zora.uzh.ch

Originally published at:
FALLOT’S TETRALOGY IN A EUROPEAN BEAVER
(CASTOR FIBER)


Abstract: A 20-mo-old, female, 9-kg European beaver (Castor fiber) presented with apathy, reduced appetite of 3-day duration and a grade 5/6 systolic heart murmur. Thoracic radiographs revealed a diffuse broncho-interstitial pattern suspicious for bronchopneumonia. The echocardiographic findings of a hypertrophied right ventricle, ventricular septal defect with overriding aorta, and infundibular pulmonic stenosis were consistent with Fallot’s tetralogy. Even though the bronchopneumonia rather than the congenital cardiac defect was considered of primary importance for the presenting clinical signs, the latter was relevant for the decision not to continue any medical treatment. Both disease processes were confirmed on necropsy.

Key words: Fallot’s tetralogy, European beaver, Castor fiber, heart murmur, ultrasound.

BRIEF COMMUNICATION

A 20-mo-old, female, 9-kg European beaver (Castor fiber) was presented to the clinic for zoo animals, exotic pets, and wildlife (University of Zurich, Zurich, Switzerland) due to apathy and reduced appetite of 3-day duration. The animal was housed at a wildlife park in an outside enclosure together with six other beavers. The size of the enclosure was 1,134 m² including a pond of 170 m² and a stream. Beside browse and access to grass, the beavers were fed with carrots, apples, beet roots, cabbage, corn, and a cereal mix. Sire and dam of the animal were both wild-caught from Germany. Eight months prior to presentation, a health check, blood sampling, and sexing had been performed. At that time, the animal was alert, in good body condition, and weighed 7.3 kg. Chest auscultation had revealed a grade 5/6 systolic heart murmur and normal lung sounds. In a blood sample taken from the tail vein, no hematologic or biochemical abnormalities were detected. Reference intervals for the American beaver (Castor canadensis) established by the International Species Information System7 were used as comparison. Further diagnostics such as thoracic radiography and echocardiography were declined by the owner.

On presentation, the animal was weak, but in good body condition. Body temperature was below 35°C. The mucous membranes were pink. A grade 5/6 systolic heart murmur was still audible during auscultation, as well as increased bronchovesicular lung sounds. Abdominal palpation revealed no abnormalities. To perform further diagnostics, it was necessary to anesthetize the animal. Isoflurane (IsoFlo, Abbot, 6341 Baar, Switzerland) in oxygen was given via a face mask. Diagnostic tests included routine hematologic and biochemical analyses, thoracic and abdominal radiographs, and echocardiography. The beaver was placed in right and left lateral recumbency on a cardiac table to acquire standard echocardiographic views using a Vivid 7 ultrasound machine (General Electric, 8152 Glattbrugg, Switzerland).13

Hematology revealed a moderate leukocytosis (27.6 × 10⁹/µL, reference value 12.5 ± 4.3 × 10⁹/µL) accompanied by neutrophilia (20.6 × 10⁹/µL, reference value 8.3 ± 3.8 × 10⁹/µL) and monocytosis (4.0 × 10⁹/µL, reference value 0.44 ± 0.42 × 10⁹/µL). Biochemical analyses were within normal reference ranges. The main abnormal radiologic finding was a diffuse broncho-interstitial pattern suspicious for bronchopneumonia. The heart silhouette and tracheal position were within normal limits compared with other clinically healthy European beavers. Pertinent findings upon two-dimensional echocardiography were a normal left ventricle, left and right atrium,
concentrically hypertrophied right ventricle, ventricular septal defect with overriding aorta, and infundibular pulmonic stenosis (Fig. 1). Doppler examination at the infundibular stenosis revealed a peak velocity of 2.8 m/s, reflecting a peak instantaneous pressure gradient of around 30 mm Hg. Assuming that the pressure gradient is likely to be underestimated under general anesthesia due to decreased myocardial contractility and cardiac output, the stenosis was judged to be of moderate severity. The peak velocity across the septal defect was 2.6 m/s from left to right. The combination of these abnormalities was consistent with Fallot’s tetralogy.

The owner opted for euthanasia because this female was in poor general condition and could not be used for breeding. At necropsy, the lungs were dark red and did not float in formalin. There was right ventricular hypertrophy, the thickness of the right and left ventricular walls being essentially the same. Beneath the pulmonic valve, the pulmonic outflow tract was narrowed by a muscular stenosis. There was a ventricular septal defect with the aorta dislocated to the right, overriding the right ventricle. Fallot’s tetralogy was confirmed on necropsy. Histologically, severe subacute pneumonia with necrotizing bronchiolitis was found.

Due to the genetic component of Fallot’s tetralogy in other species, health checks, including radiographs and echocardiography, were performed under general anesthesia on all three siblings and its dam. The sire had died in the same month and no cardiac abnormalities were found on necropsy. Anesthesia was induced in the siblings and dam with 0.7–1 mg/kg midazolam (Dormicum, Roche Pharma AG, 4153 Reinach, Switzerland) and 5–10 mg/kg ketamine (Narketan 10, Vetoquinol AG, 3063 Ittigen, Switzerland) given intramuscularly by blow dart and maintained with isoflurane in oxygen by a face mask. All animals were in good body condition and no abnormalities were detected on thoracic auscultation. Hematologic values were within normal limits. Two siblings had elevated creatine kinase (1,833 and 2,250 IU/L, reference value 1,130 ± 661 IU/L), which was thought to be due to transportation and restraint. Ventrodorsal and lateral chest radiographs showed normal shaped and positioned cardiac silhouettes. The lungs exhibited normal opacity and well-defined vessels. All echocardiographic

![Figure 1. Echocardiographic image obtained from a 20-mo-old European beaver (Castor fiber) (right parasternal long axis left ventricular outflow tract view). There is marked right ventricular hypertrophy, the thickness of the right ventricle (RV) free wall being as thick as the left ventricle (LV) free wall. There is turbulent flow across a ventricular septal defect (arrow) and the aorta (Ao) is overriding to the right ventricle.](image-url)
Fallot’s tetralogy is a congenital cardiac defect consisting of right ventricular outflow obstruction (pulmonic stenosis), secondary right ventricular hypertrophy, subaortic ventricular septal defect, and dextropositioned or overriding aorta. Congenital heart defects are commonly detected in domestic animal species but are more rarely reported in zoo and wild animals. Anomalous embryonal development may lead to congenital heart defects, and an incidence of 0.68% in dogs and 0.2–1% in cats has been reported. In cats, Fallot’s tetralogy comprises 6% of all congenital heart defects; in the dog, a frequency of less than 5% has been reported. Congenital heart disease has been described in zoo and laboratory animals, and wildlife, but Fallot’s tetralogy itself is rarely reported.

Fallot’s tetralogy is a congenital disorder that is genetically transmitted in some dog breeds such as the Keeshond and English bulldog. In view of the protected lives of pets, affected animals may be able to reproduce and promote a defect, even if the defect reduces the fitness of the animal. Congenital heart defects also develop in wild animals but are not commonly diagnosed in domestic animals because free-ranging wild animals seldom receive a clinical and particularly an echocardiographic exam. If the defects are hemodynamically relevant and reduce the fitness of the animal, then affected animals may die prematurely. In contrast, in captive wild animals, affected animals may live for a prolonged period of time and reproduce themselves, resulting in a propagation of the defect. The early detection of such a defect therefore is relevant for the future health of a captive population with a small genetic pool. A high incidence of atrial septal defects was reported in free-ranging Florida panthers (Puma concolor coryi) and was thought to be due to small genetic diversity and inbreeding. The beaver in this case report was the offspring of wild-caught parents. European beavers have gone through a bottleneck and present a low genetic diversity. However, postmortem examinations performed in 244 wild Swiss beavers from 1989 to 2009 revealed only one beaver with a ventricular septal defect (J. Wimmershoff, pers. obs.), which suggests a low prevalence of congenital heart defects in free-ranging beavers in Switzerland. Other factors such as environmental, infectious, toxicologic or nutritional status may be involved in the development of congenital heart disease and cannot be excluded in the present case.

### Table 1. Motion-mode and pulsed Doppler echocardiographic parameters in a European beaver (Castor fiber) with Fallot’s tetralogy and four healthy control beavers.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Beaver with Fallot’s tetralogy</th>
<th>Healthy beavers, n = 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight</td>
<td>kg</td>
<td>9.0</td>
<td>9.9–20.3</td>
</tr>
<tr>
<td>Age</td>
<td>yr</td>
<td>2</td>
<td>2–adult</td>
</tr>
<tr>
<td>LVVd</td>
<td>mm</td>
<td>6.4</td>
<td>4.5–7.1</td>
</tr>
<tr>
<td>LVWd</td>
<td>mm</td>
<td>22.8</td>
<td>21.5–23.0</td>
</tr>
<tr>
<td>LVVs</td>
<td>mm</td>
<td>5.5</td>
<td>4.5–6.8</td>
</tr>
<tr>
<td>LVWs</td>
<td>mm</td>
<td>6.7</td>
<td>6.1–9.9</td>
</tr>
<tr>
<td>LVDs</td>
<td>mm</td>
<td>14.6</td>
<td>12.5–14.2</td>
</tr>
<tr>
<td>LVDw</td>
<td>mm</td>
<td>8.2</td>
<td>6.6–9.4</td>
</tr>
<tr>
<td>Fractional shortening</td>
<td>%</td>
<td>36</td>
<td>38–47</td>
</tr>
<tr>
<td>Aortic root diameter</td>
<td>mm</td>
<td>1.2</td>
<td>1.2–1.5</td>
</tr>
<tr>
<td>Left atrial diameter</td>
<td>mm</td>
<td>1.7</td>
<td>1.6–2.0</td>
</tr>
<tr>
<td>LA/Ao</td>
<td>—</td>
<td>1.4</td>
<td>1.0–1.7</td>
</tr>
<tr>
<td>Ao Vmax</td>
<td>m/s</td>
<td>0.6</td>
<td>0.9–1.2</td>
</tr>
<tr>
<td>PA Vmax</td>
<td>m/s</td>
<td>0.4</td>
<td>0.8–1.2</td>
</tr>
</tbody>
</table>

*IVSd, IVSs, interventricular septum in diastole and systole, respectively.

LVVd, LVWs, left ventricular diameter in diastole and systole, respectively.

LVWd, LVWs, left ventricular wall diameter in diastole and systole, respectively.

Left atrial to aortic diameter ratio.

Ao Vmax, PA Vmax, peak velocities above the aortic and pulmonic valves, respectively.

In domestic animals with Fallot’s tetralogy, clinical signs may include poor growth, cyanosis, respiratory distress, exercise intolerance, weakness, syncope and seizures. Pets may tolerate the defect for years provided adequate pulmonary blood flow is maintained. In a 7-yr-old female free-ranging European brown bear (Ursus arctos) with Fallot’s tetralogy, which was attacked by another bear, it was concluded that circulatory collapse due to the congenital heart defect contributed to its death. Nevertheless, there was evidence that the bear had reared cubs and therefore had borne young. A newborn macaque with Fallot’s tetralogy, showing weakness and reduced body weight, died shortly after birth. In the beaver of this report, no obvious signs due to the complex congenital defect had been observed previously, and the cardiac diagnosis was an incidental finding. The infundibular pulmonic stenosis was estimated to be only of moderate severity based on the Doppler-derived pressure gradient across the stenosis, and Doppler examination of the ventricular septal defect indicated a mild to moderate gradient from left to right.
right. The lack of polycythemia suggests that the beaver did not have a large right-to-left shunt when awake. Pneumonia was considered the main cause of disease. Pneumonia is a common and significant respiratory problem in zoo mammals, and causative agents include viruses, bacteria, fungi, and parasites.

This case report describes a rare congenital heart defect in a European beaver. The uniformity of morphologic defects in certain malformations, such as Fallot’s tetralogy, observed in primates and man, carnivores (domestic felids, domestic dogs, and bear) as well as a rodent (the beaver of this study) underline how similar the genetic control of embryologic development, and hence embryologic malformations, is across mammalian species. The quantitative echocardiographic data from the healthy European beavers provide some normal values for future reference.

LITERATURE CITED


Received for publication 11 November 2009