Cardiographic Observations on a Fin-Back Whale

By Alfred W. Senft, M.D., and John K. Kanwisher, Ph.D.

For many years there has been considerable interest in recording the cardiograph of a whale. The underlying reasons for such a project are perhaps equally divided between the desire to complete a scientific comparative cardiology and the thrill of recording the heartbeat of the largest mammal. Previous partial success has been reported by King, Jenks and White, who, in 1953, obtained single lead bipolar records when electrode-harpoons were placed in the dorsum of a small (1135 Kg.) beluga whale which was captured off the Alaska Coast. In 1956, additional attempts were made to record cardiograms from healthy grey whales in the Baja California. As part of this project, special harpoon-leads were to be fired into the backs of whales from a boat or a hovering helicopter. Unfortunately, many technical difficulties frustrated these attempts to record the ECG of large whales. Thus, the task remained uncompleted until an accommodating male mysticete whale deposited himself on an accessible Provincetown beach, where the presently reported recordings were made.

Methods

The subject was a male fin-back whale (Balaenoptera physalus), measuring about 44.5 feet (13 meters) over-all and weighing an estimated 40 tons. His age was not determined, although from a comparison with such size-development charts as are available it appears he was an immature male somewhat beyond the time of weaning. The ear-wax dating method of Laws and Purves was not used.

The recording instrument was a standard clinical type Cardiotron, Model PC-3. Electric current for recording was first supplied by a portable generator (supplied by the Provincetown Fire Department). Excessively unstable and unfiltered current prevented the recording of a readable tracing. As a substitute, a long length of waterproof Christmas tree lighting cable was used to bring ordinary house current to the beach site.

From the Marine Biological Laboratory and Woods Hole Oceanographic Institution, Woods Hole, Mass. Received for publication April 25, 1960.

Figure 1

Schematic representation of recording procedure on fin-back whale.

Electrodes were fashioned out of 3-foot copper-coated steel welding rods 5/64 inches in diameter. Lamp-cord wire connected the electrodes to the instrument. The electrodes were inserted through about 7 to 12 inches of blubber until they were thought to be in contact with underlying muscle. Moving the “leg” leads from RL1-L1 to RL2-L2 improved the signal. Unfortunately, considerable AC interference is noted in most tracings. Such interference may represent grounding of the whale through wet and salty sand. Some “V” leads were obtained, but leads V5-V, were not possible, due to the prone position of the beast. A number of blowhole leads and back leads were also taken using the V-lead as the exploring electrode.

Although the whale was aground some 25 to 30 hours, cardiography was not started until 23 hours after beaching. A total of 18 recordings were taken at intermittent intervals during a 5-hour recording period. Prior to this, 4 attempts to tow the leviathan out to sea were foiled when the towing rope broke repeatedly, allowing the whale to run upon the beach again. Thus, the animal was certainly exhausted and very likely in poor condition by the time the cardiograms were made. We cannot state that he was moribund during this period, for we expected all the while that if he were taken to deeper waters, he might survive. The whale expired about 7 hours after recordings were begun. Respiratory measurements made on this animal indicated that the whale was able to extract only 2 to 3 per cent of inspired oxygen (as opposed to the normal extraction in humans of 6 per cent). The data seem to indicate that the whale died from progressive anoxia presumably due to lung and heart compression secondary to his being beached.
Results

A representative 15-lead cardiogram, showing “limb” leads, augmented leads, precordial traces, blowhole (BHL), and back (BK) (BK(F)) leads are shown in figures 2A, 2B and 2C.

Measurements of the duration of certain complexes which are frequently used in clinical cardiology are recorded in table 1. These data have been arranged so as to allow a comparison with other mammals ranging from about 15 Gm. to 1,000 Kg. It will be noted that with increasing body mass of larger mammals, the heart rate decreases, while showing a concomitant increase in P-R, QRS and Q-T times.

The whale’s rate showed little variation between 27 to 32 beats per minute, although a deep inspiration would result in marked bradycardia. Since the complexes are fairly

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Mouse</th>
<th>Baboon</th>
<th>Man</th>
<th>Elephant</th>
<th>Beluga whale</th>
<th>Fin-back whale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight</td>
<td>15 Gm.</td>
<td>20 Kg.</td>
<td>70 Kg.</td>
<td>3700 Kg.</td>
<td>1136 Kg.</td>
<td>32,000 Kg.</td>
</tr>
<tr>
<td>Rate/min.</td>
<td>600-780</td>
<td>100-140</td>
<td>50-88</td>
<td>94-95</td>
<td>12-24</td>
<td>27-22</td>
</tr>
<tr>
<td>P-R interval (sec.)</td>
<td>0.03-0.04</td>
<td>0.08-0.15</td>
<td>0.14-0.19</td>
<td>0.28-0.41</td>
<td>0.32</td>
<td>0.08-0.73</td>
</tr>
<tr>
<td>QRS interval (sec.)</td>
<td>0.008-0.011</td>
<td>0.01-0.07</td>
<td>0.06-0.11</td>
<td>0.12-0.18</td>
<td>0.09-0.12</td>
<td>0.32-0.34</td>
</tr>
<tr>
<td>Q-T (sec.)</td>
<td>—</td>
<td>0.2-0.3</td>
<td>0.27-0.41</td>
<td>0.59-0.79</td>
<td>0.36-0.40</td>
<td>0.96-1.08</td>
</tr>
<tr>
<td>T (mm.)</td>
<td>0.5-4.4</td>
<td>1.0-5.0</td>
<td>0.5-2.0</td>
<td>1.0-1.5</td>
<td>10-13</td>
<td></td>
</tr>
</tbody>
</table>

*Values are approximate and ( ) indicates average.
closely spaced, we believe this is nearly the maximum rate for this animal. This is also reasonable in view of the apparent respiratory difficulty and the compression of the chest wall. On the basis of body size, a rate of 10 per minute would have been expected. The P-R interval of 0.68 to 0.73 seconds is twice that of the beluga whale which had a pulse rate as low as 15 per minute.

P waves, as seen in A_vR and V-leads are biphasic, with an initial positive deflection. Duration of this biphasic deflection is about 0.4 of a second; QRS duration was 0.28 to 0.34 of a second long. Maximum measurable deflection is about 21 mm. (V2r), although some of the signal was attenuated as the deflection exceeded the limits of the recording instrument (fig. 3). The electrical position of this heart is semihorizontal.

As in most other mammals (man being an exception) there is discordance of direction of T as compared with QRS. A biphasic QRS (as in A_vR and A_vL) is followed by inversion of the T wave. Maximum T-wave deflection, measured in precordial leads, was about 13 mm.

The lead taken with an exploring electrode about 12 inches down the blowhole shows characteristics similar to A_vL. The cephalad back lead, BK, and the caudal back lead BK(F) show sharp reversal in direction of both QRS and T, as the electrode is moved caudad. It is of interest to note that the dorsal back lead BK(F) which we obtained corresponds in some details to the "dorsal lead" shown in the beluga whale.1

Abnormal complexes are seen in leads 1 and V5. These leads appear to represent ectopic ventricular or A-V nodal foci. Lead V5 illustrates several ectopic beats in sequence followed by a compensatory pause.

Summary
The beaching of a 40-ton fin-back whale on a Provincetown shore provided a fortuitous opportunity for taking the first cardiograms of the largest mammal. A representative 15-lead cardiogram is shown. This does not differ materially from other large mammals, except that the time scale of events is extremely prolonged. Abnormal foci of ventricular beats and compensatory pauses are illustrated.

Acknowledgment
The kind help of Drs. Paul D. White and Benjamin Kaminer in reviewing our records is gratefully acknowledged.

Summario in Interlingua
Le accidénte quo un roquale de 40 tonnas de peso se doponova al plagia de Provincetown provideva le opportunitate de obtenre le prime cardiogrammas del plus grande mammal. Un representative cardiogramma de 15 derivationes es mostrate. Illa non differe materialmente ab registrationes cardiographiche
in altera grande mammalibus, excepto que le mesuras de tempere es extremamente prolongate. Es illustrate focos anormal de pulso ventricular e pausas compensatorii.

References
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Circ Res. 1960;8:961-964
doi: 10.1161/01.RES.8.5.961

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