Surgical procedure for implanting a radiotelemetry transmitter to monitor ECG, heart rate and body temperature in small *Carassius auratus* and *Carassius auratus gibelio* under laboratory conditions

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Summary

Radiotelemetry provides an alternative means of obtaining physiological measurements from conscious and freely moving animals, without introducing stress artefacts. A surgical procedure is described for implanting radiotelemetry transmitters to monitor the electrocardiogram (ECG), heart rate (HR) and body temperature (BT) in small goldfish (*Carassius auratus*; 50–100 g) and Prussian carp (*Carassius auratus gibelio*; 100 g). This type of transmitter is commonly implanted in freely moving mice. After surgery and a recovery period of 24 h, the ECG, HR and BT were recorded in freely swimming fish within the limitations of the aquarium.

Keywords Telemetry; electrocardiogram; surgical techniques; goldfish; Prussian carp

Radiotelemetry can be considered as a technique for measuring many physiological parameters in small fish under laboratory conditions, giving new possibilities for research in biology and physiology. The technique provides an alternative means of obtaining physiological measurements from living animals within the limitation of their housing conditions. An advantage is that, after recovery of the small animals, no stress artefacts are introduced (Kramer 2000, Kramer *et al.* 2001). Until now, radiotelemetry devices were implanted only in fish of more than 575 g (Lucas & Johnstone 1993, Thorreau & Baras 1997, Anderson *et al.* 1998). In literature several studies are known, in which heart rate frequencies of small fish were measured by placing a radio transmitter dorsally outside the body (body length ca 230–500 mm, too large) (Cooke *et al.* 2002, Rinne *et al.* 2002). A disadvantage of this approach is that the animal is affected in its swimming behaviour because the transmitter exerts a negative effect on the drag of the swimming fish. In the present study, the implantation technique of a radiotelemetry transmitter was performed on seven goldfish (*Carassius auratus*; 50–100 g, ca 68–105 mm body length) and three Prussian carp (*Carassius auratus gibelio*; 100 g, ca 165 mm body length), in order to monitor electrocardiogram (ECG), heart rate (HR) and body temperature (BT). As 100 g goldfish were not available commercially, we proceeded with Prussian carp.

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Materials and methods

Surgery

Telemetry transmitters of the type TA 10ETA-F20-L20 (Data Sciences International, DSI, St Paul, MN, USA) were used. Their dimensions are: length 21 mm; height 10 mm; width 11 mm; weight in air 3.3 g. A major advantage of this type of transmitter, under conditions of continuously monitoring, is that the battery life is rather long (6 months). Moreover, the battery can be switched on and off magnetically, resulting in an even longer lifetime. The transmitters were implanted in goldfish and Prussian carp with increasing body weight (50, 60, 80 and 100 g). First, the fish were anaesthetized in a 50–100 ppm MS-222 aqueous solution, depending on body weight. A 1.5 cm incision was made dorso-caudal of the implantation of the pectoral fin, just caudal to the pectoral girdle and the transmitter body was fixed in the abdominal cavity with one stitch to the basipterygia of the pelvic girdle. The positive electrode was glued with dextroflavum in water solution to a longitudinal grinded hypodermic needle (Nuijens *et al.* 1997) and inserted from the abdominal cavity through the septum transversum into the pericardial cavity. Injecting the hypodermic needle with tepid physiological salt solution dissolved the glue. Then, the needle was withdrawn while leaving the electrode in place. The same procedure was used to place the negative electrode in the hypaxial musculature. After this procedure, the fish were returned individually to their aquariums. The experiments were authorized by the local ethical committee on animal experiments.

Data collection

The monitoring system to measure ECG, HR and BT consisted of: (1) a receiver board (RPC-1, DSI), placed under the aquarium (length 30 cm; height 15 cm; weight 20 cm), monitoring the transmitter signal; (2) a multiplexer (Data Exchange Matrix, DSI) consolidating signals from multiple transmitters; (3) an IBM-compatible personal computer (Compaq Presario 1510) with data capture and analysis software (Dataquest ART 1.01, DSI). The total set-up was placed in a temperature-controlled room (16°C) that kept the water temperature constant at 15°C, with a 12:12 light–dark cycle. X-ray pictures were made (Deffractis 581, exposure: 15 kV, 20 Am, 2 min) to monitor the enlargement of the swim bladder, in compensation for the weight of the implanted transmitter. The pulsing heart of one goldfish was videotaped using a high-speed digital video with 250 fields/s, 1/1000 s shutter speed (Kodak Motion corder analyser SR500 series; Zeist, The Netherlands) synchronized with the HR to analyse the waveform.

Results

Except for the 50, 60 and 80 g goldfish (see Discussion), transmitter implantation in the four goldfish of 100 g and three Prussian carp (100 g) used in this study was successful (Figure 1). Within 24 h the fish compensated for the weight of the implanted transmitter by enlarging the swim bladder. One hour after recovery from the anaesthesia, HRs of 70–80 beats per minute (bpm) were recorded. After 24 h, the HR was stable for both species and the average HR ranged from 50 to 60 bpm (Figure 2). A minimum of 18 bpm and a maximum of 85 bpm were registered. When the fish were disturbed, e.g. during feeding, the HR decreased to minimum. Characteristic ECGs could be monitored

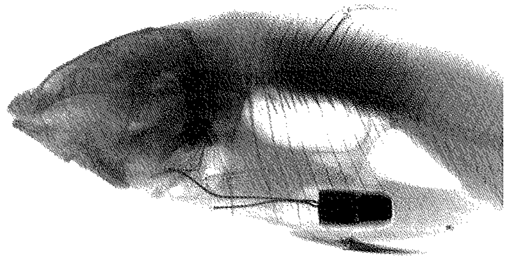

Figure 1 X-ray of 100 g Prussian carp 14 days after implantation of transmitter

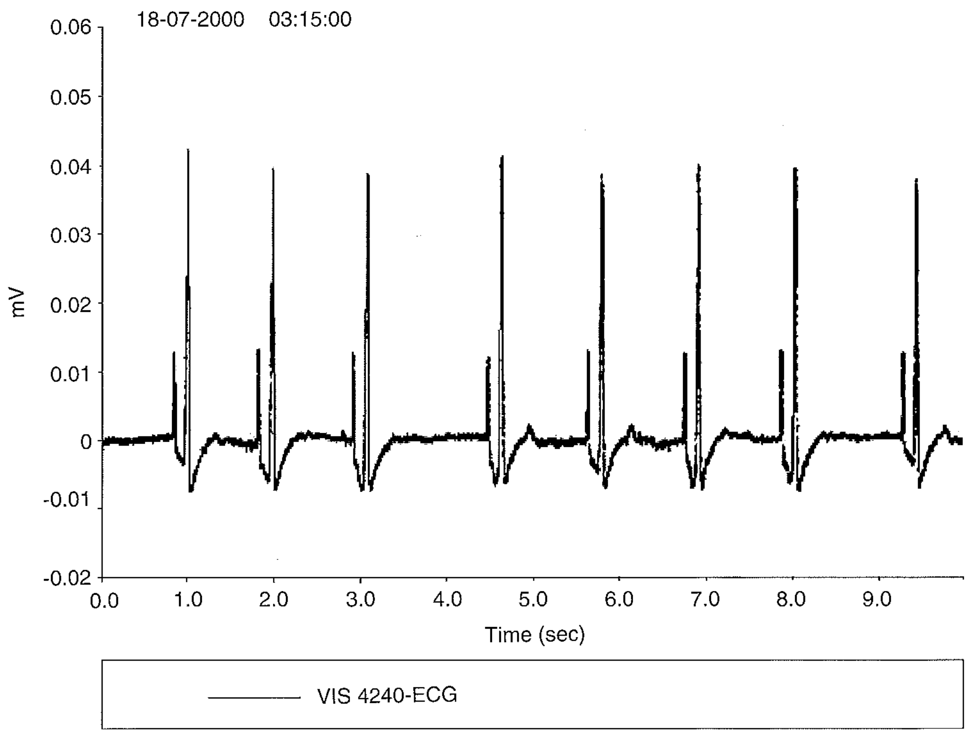

Figure 2 Electrocardiogram of a goldfish 24 h after implantation of transmitter

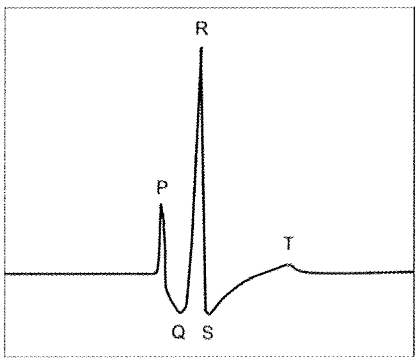

Figure 3 Analysing the goldfish heart at high-speed video synchronies with ECG (Figure 2). The P wave is associated with a contraction of the sinus venosus, QRS complex atrial contraction and the T wave with ventricular contraction

(Figure 3). BTs were the same as the water temperature (15°C), and no circadian rhythms of HR and BT were found in any fish during the 24 h recording periods.

Discussion

It appears to be possible to implant a transmitter to monitor ECG, HR and BT by radiotelemetry in free swimming fish at presumably relatively low levels of stress. Radiotelemetry enables direct and accurate measurements of changes in physiological parameters due to environmental changes. In fish research, this can be applied in stress physiology, aquatic toxicology, ecology and behavioural studies under controlled laboratory conditions. Due to the limited space in the abdominal cavity, in 50, 60 and 80 g goldfish, the introduction of the transmitter and the subsequent gradual increase in size of the swim bladder had a negative effect on the postoperative recovery. Increased tension on the closed incision of the abdominal cavity prevented the healing process and caused infection of the wound. These fish with non-healing wounds were euthanized as soon as they were observed. The 100 g goldfish and Prussian carp showed almost no sign of an extended abdomen, which resulted in the healing of the incision within 10 days. Therefore, we conclude that these small telemetry transmitters can be used without stress artefacts in small goldfish and Prussian carp of more than 100 g to measure physiological parameters. Finally, after four months, the ECG of the three Prussian carp could still be monitored.

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