Effects of anesthesia and surgery on the blood composition of chum salmon, *Oncorhynchus keta*

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Abstract

Telemetry is a valuable technique for elucidating salmon behavior but it is important to establish the time required for recovery before fish can be safely released after anesthesia and surgical attachment of telemetry devices. To ensure that fish swim normally in experiments after surgical tagging, recovery can be determined using indices of stress and blood conditions. This study examined the time course of return to normal of blood parameters of chum salmon following anesthesia and surgical attachment of a telemetry transmitter. Sixteen blood parameters were assessed: pH, pCO_2, pO_2, BE (Base Excess), HCO_3, tCO_2, sO_2, Lact (Lactate), Na (Sodium), K (Potassium), Cl (Chloride), Glu (Glucose), Hct (Hematocrit), Hgb (Hemoglobin), cortisol and testosterone. Blood was sampled by cannulation to avoid stressing the fish, at the following times after tagging: 0, 3, 6, 12, 24, and 30 h. Values of pCO_2, pO_2, sO_2, Hct, Lact and pH returned to normal after 1–6 h. There were no significant changes in the levels of the stress hormone cortisol during the sampling period. The values of other parameters also did not differ during the sampling period. In light of these findings, chum salmon can be safely released 6 h after transmitter tagging.

Keywords: chum salmon, surgery, anesthesia, blood parameter, recovery time

Introduction

Understanding the migratory behavior of fish is critically important because of increasing threats posed by human activities such as overfishing and dam construction. Telemetry is a useful method for elucidating fish behavior.

Fish telemetry research involves anesthesia, surgery and recovery followed by release into the field for behavioral tracking, or by laboratory experiments [1]. Following anesthesia and surgery, adult Pacific salmon initially exhibit abnormal behavior (e.g., wide gill flapping) and they require at least ten minutes to regain normal orientation in the water (i.e., dorsal fins positioned vertically) after regaining consciousness. However, longer holding periods stress fish and result in higher mortality rates [2] and a greater risk of damage to, or detachment of, telemetry equipment [3]. Therefore, fish should be released as soon as possible after they recover and are able to swim normally following attachment of the telemetry equipment.

Recovery periods after transmitter attachment have been reported as 2 h to 13 days before release into the field [4–5], although some studies relied only on visual observations of fish behavior. Recently, the time required for fish to recover with respect to oxygen consumption (MO_2) and swimming ability (U_{crit} and EMG values) following the attachment of telemetry devices was resolved [6]. It is also important to verify complete recovery after surgical tagging, using a stress index and changes in blood constituents, to ensure that tagged fish are physiologically capable of swimming normally in experiments.

This study examined the time course of return to normal levels of certain blood parameters in chum salmon after anesthesia and surgical attachment of a telemetry transmitter.

Materials and Methods

Study animals, handling, and experimental conditions

Twenty-six adult chum salmon (mean ± SE; fork length: 65.7 ± 3.0 cm; body weight: 3.30 ± 0.51 kg) of both sexes were used during their upstream spawning migration. Experiments were conducted at the Chitose Salmon Aquarium in October 2011. Fish were individually transferred to columnar compact fish cages (L × D = 1.2 × 0.2 m) in an artificially flowing stream. Fresh water from the Chitose River was used in all experiments. Cannulation blood sampling was used to avoid stressing the fish. Sixteen blood parameters were assessed: pH, pCO_2, pO_2, BE, HCO_3, tCO_2, sO_2,

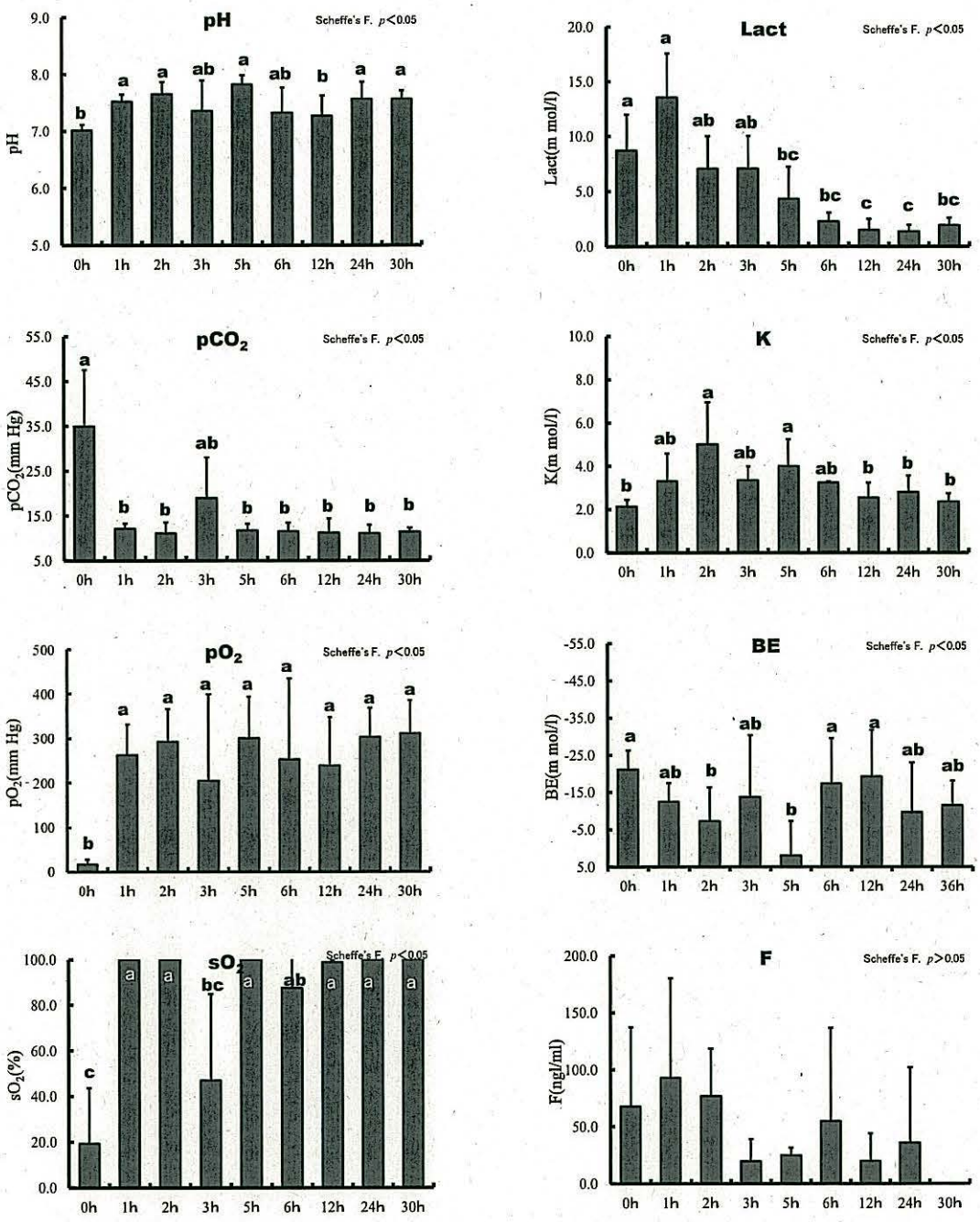

Fig. 1: Time course of changes in blood parameters

Lact, Na, K, Cl, Glu, Hct, Hgb, cortisol (F) and testosterone. The blood parameters were assessed at 0, 3, 6, 12, 24, and 30 h after tagging. Blood parameters were measured using an i-STAT system (Abbott Point of Care Inc., IL, USA).

Transmitter attachment procedures

After cannulation surgery, all fish were provided with 24 h of acclimatization. They were then anesthetized with 0.5 ml L^{-1} FA100 (eugenol; Tanabe Seiyaku, Osaka, Japan) for about 8 min, and EMG transmitters were attached externally using a standard procedure developed by Hayashida et al. [6]. Briefly, EMG transmitters (CEMG-R11, Lotek Engineering, Newmarket, Ontario, Canada: 18.0 g, 16.0 mm diameter, 53.0 mm long) were pushed through the dorsal muscle using nylon ties; Teflon-coated electrodes with brass muscle-anchoring tips (dimensions: 5 × 1 mm) were inserted subcutaneously using a hypodermic needle at approximately 0.7 times the body length, on the left side of the fish. Paired electrode tips were positioned approximately 10 mm apart and secured in the lateral red muscle

toward the rear of the fish. The surgery took about 7 min, during which the fish were exposed to air and their gills were irrigated.

Results & Discussion

The seven blood parameters of pH, pCO_2, pO_2, sO_2, Lact, K and BE showed significant changes during sampling. Although blood levels of the stress hormone cortisol (F in Fig. 1) fluctuated during sampling, there were no significant changes. The values of other parameters also did not differ during the sampling period. It took 1–6 h for pH, pCO_2, pO_2, sO_2, Lact, K and BE to return to normal (we assumed that the stable values observed after 24–30 h represented the normal state). The values of pH, pCO_2, pO_2, and sO_2 showed particularly notable increases or decreases at 1 h after surgery compared to the values immediately after surgery (0 h in Fig. 1); the values then gradually stabilized. More specifically, it is evident that by 1 h after surgery the value of blood pCO_2 had significantly decreased from that immediately after surgery (0 h) while pO_2 quickly increased immediately after the surgery (1 h) and blood pH shifted from neutral to alkaline. No parameters showed significant changes in values subsequent to 1 h after the surgery. It is considered that the above-mentioned changes were associated with the abnormal conditions occurring after surgery; that is, anesthesia and exposure to the air imposed a physiological burden on the fish, after which the fish began to recover (from approximately 1 h after surgery). The value of Lact peaked 1 h after surgery and the value of K peaked 2 h after surgery. K is the causal substance of muscle fatigue, and high levels of K are said to cause some of the abnormalities that are seen on electrocardiograms, or to cause arrhythmia [7]. In contrast, it is assumed that the values of Lact and K peaked at different times because Lact has the effect of controlling muscle fatigue. It is also assumed that the Lact values changed because muscle fatigue that had occurred before the surgery or the lack of oxygen during the surgery continued even after surgery, with full recovery not being complete until 5 h later.

Conclusions

This study revealed that changes in blood parameters of chum salmon are not caused by cannulation surgery or surgical attachment of a transmitter; they are caused by the exposure of fish to the air during surgery following anesthesia. In light of these findings, chum salmon can be safely released 6 h after transmitter tagging.

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