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INSIDE JEB

Trout recover from heart attack damage

Farm-produced rainbow trout (*Oncorhynchus mykiss*) in an aquarium in a fishmonger in Kozan, Adana, Turkey. Photo credit: Zeynel Cebeci, CC BY-SA 4.0, via Wikimedia Commons.

Most fish's hearts have to scavenge whatever oxygen is left in the poorly oxygenated blood returning from the body, absorbing what remains of the life-giving gas through the spongy myocardium. But not super athletic salmonids. Their hearts benefit from a well-oxygenated blood supply to the outer layer of the ventricle, the chamber that pumps the blood through the gills and body. However, this arrangement leaves their hearts vulnerable if the blood supply to the ventricle is disrupted by heart disease, and wild and farmed members of the family are particularly prone to the problem. 'In fact, coronary arteriosclerosis has been described as a "fact of life" in salmonids', says Lucas Zena from University of São Paulo, Brazil. Zena, along with Erik Sandblom and colleagues from The University of Gothenburg, Sweden, and the Swedish University of Agricultural Sciences, were curious to find out whether trout hearts could recover from an interruption to the heart's blood supply and, if so, how?

Operating on several fit young trout to restrict the blood flow to the ventricle and simulate short (3 day) and longer (33–62 day) episodes of heart disease, the team then tested how the disruption affected the performance of the heart, how the heart reacted over time and whether it was able to recover at all.

Recording the fish's heart rate shortly after losing the blood supply, Zena found that the resting rate had increased from ∼37 beats min^{-1} to ∼49 beats min^{-1}. However, maximum heart rate when exercising was unaffected, despite the lack of blood to the ventricle; they could exercise as hard as healthy fish, but they had less capacity to ramp up their heart rate on demand. But, when the team measured the resting heart rate after fish had experienced 2 months of simulated heart disease, they found it had returned to the more leisurely pace of the healthy fish. And, when the team tested the heart rate variability – the variation in time between consecutive heartbeats – they found it was much lower in newly operated fish than in those with a good blood supply. However, the fish that had experienced an interruption to the blood flow to the heart for a month or more had overcome the problem; their heart rate variability was essentially the same as that of healthy fish of the same age.

The team then looked at the state of the fish's hearts 3 days after the interruption of the blood supply and realised that they were experiencing the same damage as human heart attack victims: losing muscle tissue and showing signs of inflammation. But, after 2 months the fish had developed a scar – a fibrous layer composed of collagen – running throughout the outer layer of heart muscle, dividing the most external region of the heart from the internal layer. 'It is possible that the mid-myocardial fibrous layer demarks a region of the compact myocardium that continued to receive oxygen from the luminal venous blood', says Zena.

So, young trout are able to recover from an interruption of the oxygen supply to the heart, and Sandblom and colleagues are keen to find out how well the fish's cardiac adaptability protects the fish from stressful situations.

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Zena, L. A., Ekström, A., Gräns, A., Olsson, C., Axelsson, M., Sundh, H. and Sandblom, E. (2021). It takes time to heal a broken heart: ventricular plasticity improves heart performance after myocardial infarction in rainbow trout, *Oncorhynchus mykiss*. *J. Exp. Biol.* **224**, jeb243578. doi:10.1242/jeb.243578.

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