

**HYPOXIA DEFENSE STRATEGIES OF THE  
AMERICAN EEL (*ANGUILLA ROSTRATA*) HEART**

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**EXTENDED ABSTRACT ONLY - DO NOT CITE**

The American eel (*Anguilla rostrata*) survives prolonged air-exposure during which time oxygen consumption must be compromised. A comprehensive picture of the strategies utilized in hypoxia defense by the heart of the American eel is emerging.

Foremost, oxygen consumption by perfused-isolated hearts continues as extracellular PO<sub>2</sub> levels approach zero due to high levels of myoglobin. This is in marked contrast to hearts from other species that may cease to consume oxygen at a PO<sub>2</sub> around 40 mmHg (Bailey et al., 1990). Performance by isolated and intact hearts or ventricle strips when exposed to severe hypoxia or poisoned with cyanide is decreased by inherent mechanisms to levels of sustained contractility that are about 25% of the normoxic values. This low level of sustained performance under oxygen limiting conditions is dependent upon extracellular glucose as in the absence of glucose, isolated heart preparations rapidly fail. Under these conditions on board glycogen is utilized, as glycogen stores are not protected by extracellular glucose (Bailey et al., 2000b). Utilization of extracellular glucose is in part a result of enhanced uptake mechanisms. Uptake of 2-deoxyglucose by ventricular strips was increased 45% by one hour of severe hypoxia. This increase was completely inhibited by cytochalasin B implying glucose utilization is in part supported by activation of glucose transporters. It is probable that similar to mammalian systems glucose transporters are being mobilized from intracellular vesicles (Rodnick et al., 1997). Enzyme activities levels of ATP demand and supply are matched to glucose utilization under anaerobic conditions. The maximal in vitro activity of total ATPase in an assay system designed to maximize the contribution of myofibrillar ATPase is similar in magnitude to the ATP equivalents that could be

released from glycolysis based on hexokinase activity (Bailey et al., 1991). Thus, the basic strategies for surviving hypoxia include effective oxygen extraction at low PO<sub>2</sub>, reduced levels of performance (i.e. energy demand), use of glucose via activation of transporters, matching ATP demand with high levels of hexokinase, and use of glycogen stores.

Further detailed studies suggest an additional and surprising element to the hypoxia defense paradigm. Cyanide poisoning results in an inability of ventricular strips from eel heart to relax following contraction (Bailey et al., 1999). This inability to maintain resting tension under cyanide poisoning is not ameliorated by extracellular glucose (Bailey et al., 2000a). The inability to relax, that is an increase in resting tension, is considered to be due to an accumulation of cytosolic Ca<sup>2+</sup>. Under aerobic conditions an increase in extracellular Ca<sup>2+</sup> results in increases in resting tension of ventricular strips in the absence of metabolic fuel. Increases in extracellular Ca<sup>2+</sup> in this experimental protocol are considered to result in increases in intracellular Ca<sup>2+</sup>. If glucose, pyruvate, or pyruvate plus iodoacetate are present in the bathing medium resting tension is maintained in the face of an extracellular Ca<sup>2+</sup> challenge. This implies that aerobic metabolism supported by an extracellular fuel is required to reduce intracellular Ca<sup>2+</sup> that in turn leads to relaxation. This contention could be applied to the eel heart under oxygen limiting conditions. It is suggested that in order for relaxation to fully occur there needs to be some aerobic metabolism supported by an extracellular fuel. It may be that eel hearts can perform well under severe hypoxia but not total anoxia. A further implication is that some aspect of the mechanism by which cytosolic Ca<sup>2+</sup> is decreased is dependent upon ATP generated by mitochondria.

## References

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