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Scott and Laura Eller Congenital Heart Center
Caring for Hearts for a Lifetime

# Impact of Inspired Oxygen Concentration on Cerebral Blood Flow in Univentricular Circulation

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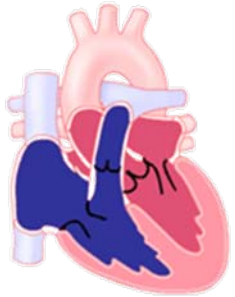
## Objective

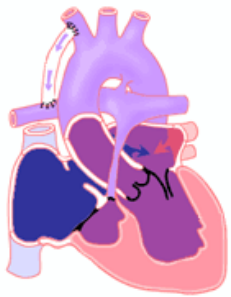
To assess the effects of fraction of inspired oxygen (21% $FiO_2$ versus 100% $FiO_2$) on cerebral blood flow in univentricular circulation.

## Background

Single ventricle is a fatal congenital heart defect which appears immediately after birth and requires a series of surgical procedures to allow the one functional ventricle to provide adequate blood supply to the lungs (pulmonary circulation) and the rest of the body (systemic circulation). Survival depends on a parallel connection between the two circulations called "pulmonary-to-systemic shunt".

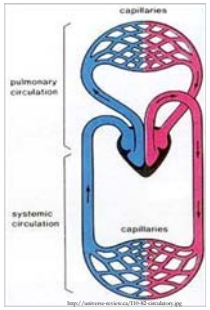


Normal Heart

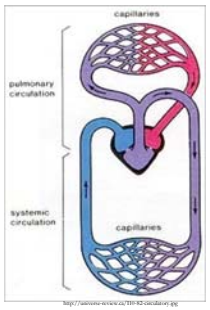


Single Ventricle with Systemic to Pulmonary Shunt

In univentricular circulation, oxygenated and deoxygenated blood mix together in a single ventricular chamber, and mixed blood is distributed to the pulmonary and systemic circulations based on their relative vascular resistances and the size of the shunt. This blood mixing causes "cyanosis".




Normal Circulation



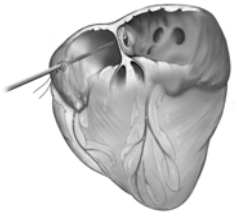

Univentricular Circulation

Unlike normal circulation where pulmonary flow equals systemic flow, univentricular circulation usually implies higher pulmonary flow due to the normally lower pulmonary vascular resistances (PVR). PVR becomes even lower by increasing $FiO_2$. This diminishes systemic flow impairing organ function and long-term survival.

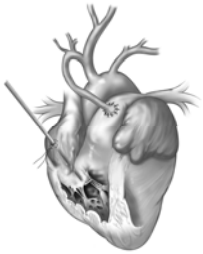
## Methods

Univentricular circulation was established in 10 neonatal piglets. Systemic-to-pulmonary shunt was created by dissecting and sectioning the right subclavian artery and anastomosing it to the main pulmonary artery. The foramen ovale was fenestrated using a nerve hook and Fogarty balloon catheter to establish an atrial septostomy. The tricuspid valve was rendered incompetent by destroying its leaflets and chordae tendineae with a nerve hook. Finally, the main pulmonary artery was occluded.

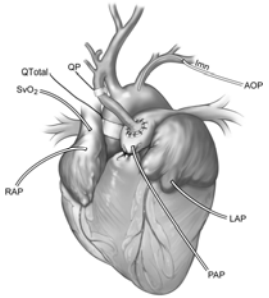
Systemic to Pulmonary Shunt

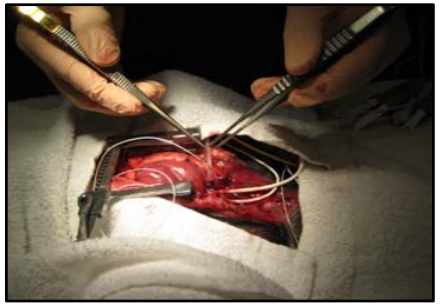


Atrial Septostomy



Tricuspid Avulsion



**Measurements:**
Cardiac output (CO), Pulmonary flow (Qp), and Carotid flow (Qc) were measured using Transonic flow probes. Blood pressures were measured using Millar catheters. Blood gases were measured with arterial and venous blood oximeter and a blood gas analyzer.

**Calculated Parameters:**
Systemic flow (Qs), Pulmonary/Systemic flow ratio (Qp/Qs), Carotid/Systemic flow ratio (Qc/Qs), and Oxygen extraction ($O_2$ER).

**Compared Parameters :**
The data collected during "normoxia" (21% $FiO_2$) and "hyperoxia" (100% $FiO_2$)

## References

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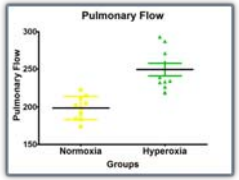
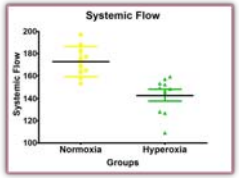
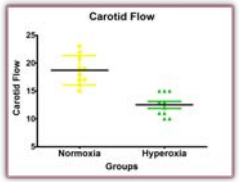
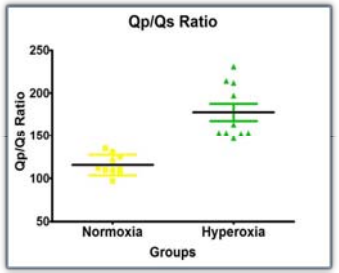
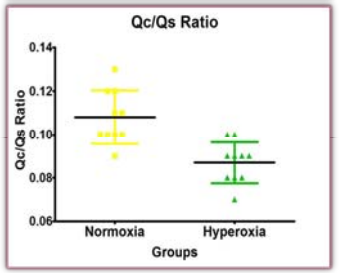
## Results




**Increasing $FiO_2$ from 21% (normoxia) to 100% (hyperoxia):**

**Increased:**
Qp/Qs Ratio (Pulmonary/Systemic Flow Ratio), Pulmonary flow, and $O_2$ Extraction Ratio

**Decreased:**
Carotid Flow (by 23%), Systemic Flow (by 17%), Qc/Qs Ratio (Carotid/Systemic Flow Ratio)

## Conclusion

**Is more oxygen better?**

Increasing $FiO_2$ from 21% to 100% in this univentricular model diverted a significant amount of blood flow to the lungs, reducing systemic blood flow and tissue perfusion. The effects were more pronounced on carotid flow than overall systemic flow. Therefore, by reducing carotid blood flow and tissue perfusion, hyperoxia may have adverse effects on cerebral perfusion and neurological function in newborns with univentricular circulation.

## Acknowledgements

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