Cardiovascular Alterations and Multiorgan Dysfunction After Birth Asphyxia

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KEYWORDS

• Asphyxia • Cardiovascular • Multiorgan failure • Kidneys • Liver

KEY POINTS

- The cardiovascular consequences of asphyxia likely underlie downstream multiorgan injury.
- The major mechanism is redistribution of blood flow and oxygen delivery to vital organs, resulting in poor perfusion and hypoxia in other organs.
- Current clinical management needs to consider the cardiovascular effects of therapeutic hypothermia on the asphyxia-mediated organ dysfunction and recovery.

INTRODUCTION

Birth asphyxia causes hypoxic-ischemic encephalopathy and multiorgan failure. The most studied organ affected by hypoxia is the cardiovascular system, and the resulting hemodynamic instability that occurs because of hypoxia, either in utero or during resuscitation and newborn transition, causes downstream effects on other organs. The clinical focus during the resuscitation of asphyxiated infants is largely on the immediate changes in heart rate and systemic blood pressure that occur at delivery, based on the seminal findings of Dawes,[1] Cross,[2] and Dawes and colleagues.[3] The acute cardiorespiratory consequences of asphyxia require rapid intervention in the form of stimulation, ventilation, and in extreme cases cardiac resuscitation.[4]

However, other cardiovascular consequences of asphyxia can also have long-term consequences to asphyxic newborns. One of the profound cardiovascular responses to asphyxia is the redistribution of cardiac output. Hypoxia diverts blood, partially through a primitive diving reflex, from less vital organs, such as the liver, kidney,

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and gut, to maintain oxygen delivery to critical organs such as the adrenal gland, heart, and brain, at the expense of other organs.[5–7] Within these organs now deprived of blood flow, local vasoconstriction and redistribution of blood flow results in a decrease in oxygen delivery.[7] If prolonged, this can cause cellular injury and inadequate tissue function and can result in multiorgan dysfunction after birth. Further, the fetal cardiovascular response to asphyxia can also lead to redistribution of blood volume toward the placenta, leaving the asphyxic newborn volume depleted and prone to circulatory shock.

All the clinical manifestations of organ failure must be managed in the setting of therapeutic hypothermia. Although much of perinatology has been focused on the downstream consequences of asphyxia on the brain, and the serious consequences of hypoxic-ischemic encephalopathy (HIE), a growing appreciation of the consequences of asphyxia on other organs is emerging (**Table 1**),[8–11] which further complicates the care of asphyxiated infants.

This article describes the circulatory responses to asphyxia and how they can lead to multiorgan dysfunction. It focuses on the physiologic derangements that occur in response to hypoxia, and the end-organ damage caused by both the hypoxia and the hypoperfusion caused by responsive shunting of blood. It also briefly outlines the current clinical strategies for minimizing multiorgan injury to attempt to reduce lifelong morbidity.

CARDIOVASCULAR RESPONSE TO ASPHYXIA

Irrespective of the cause of impaired gas exchange, there is a sequence of cardiovascular and respiratory changes that ensue in asphyxiated infants at birth. Shortly after the onset of asphyxia, the newborn undergoes a period of primary apnea that is also associated with a profound bradycardia.[1,2,12,13] Blood pressure is usually maintained during primary apnea because of peripheral vasoconstriction and the redirection of blood from nonvital organs toward the heart, central nervous system, and adrenal glands.[5,6,14–18]

If asphyxia continues, after a period of gasping the fetus enters secondary apnea or terminal apnea.[15,19] Secondary apnea is associated with a large decrease in blood pressure[12,19] and, without intervention, the newborn eventually has cardiac arrest.[12,19]

Table 1
Multiorgan failure after birth asphyxia in randomized therapeutic hypothermia trials

	Selective Head CoolCap[8]		Whole-body NICHD[9]		Whole-body TOBY Trial[10]		Selective Head Chinese Trial[11]	
Study	**Cooled**	**Control**	**Cooled**	**Control**	**Cooled**	**Control**	**Cooled**	**Control**
Increased Liver Enzyme Levels (%)	38[a]	53	20	15	NR	NR	35	28
Thrombocytopenia (%)	33	22	NR	NR	58	50	6	2
Prolonged Coagulation (%)	50	42	18	11	41	43	NR	NR
Hemorrhage/ Bleeding (%)	NR	NR	3	2	NR	NR	3	2
Renal Failure (%)	65	70	22	26	ND	ND	23	22

Abbreviations: ND, none requiring dialysis; NICHD, National Institute of Child Health and Human Development; NR, not reported.

[a] $P<.05$ verses control infants.