

A Historical Perspective on the Development of Modern Concepts of Tissue Perfusion

Prehistory to the Twentieth Century



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KEYWORDS

• History • Perfusion • Physiology

KEY POINTS

- The modern concept of perfusion encompasses a variety of anatomic, physiologic, and biochemical ideas. These are incorporated into a model of how the body delivers fuel substrates and oxygen to target tissues for their conversion into energy that the body uses for the biochemical processes of life and how the body removes the waste byproducts that occur during these biochemical processes.
- The modern concept of perfusion has largely grown out of discoveries that have taken centuries of scientific inquiry.
- The concept of tissue perfusion continues to evolve and develop.
- Although the basic groundwork of tissue perfusion was completed by the middle of the twentieth century, there continue to be discoveries and refinements of understanding. As the means of exploring the intracellular milieu improve, additional links become apparent.
- These new discoveries are also opening the door to new ways to bring theoretic knowledge to bedside monitoring and care.

INTRODUCTION

Few processes are more basic to life than the delivery of oxygen and nutrients to cells and the removal of carbon dioxide and waste products from them. Without these functions, cellular metabolism and work stop and the cell dies (or must go into a state of

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suspended animation). In single-celled organisms, these actions are accomplished through direct contact with the environment. In more complex organisms, these fundamental activities become significantly more complex. Multiple cell types with specific functions and arranged in specific positions move the necessary metabolic substrates from the external environment to the internal one. Once internalized, the substrates are distributed according to the utilization of the target cells. Yet despite this complex system, the basic nature of the process remains: deliver oxygen and nutrients while removing toxic metabolic byproducts. Given the importance of this process in mammalian biology, it is remarkable how difficult the concept of perfusion has been for the medical sciences to unravel and understand.

The origins of the concepts that eventually formed the current understanding of perfusion are convoluted. The fundamentals of circulation have been discovered and rediscovered and arranged and rearranged until finally placed in a formal framework in the 1600s. Once a formal understanding of the circulatory system became more widely accepted and agreed on, a series of ever more complicated pieces of the puzzle layered on one another until modern times. Tissue perfusion is now viewed as a web of anatomy, physiology, and biochemistry. So fundamental a topic to mammalian biology and medicine as tissue perfusion would be thought firmly quantified and conceptualized by the time of modern medical science. Understanding of what happens at the cellular level, however, continues to evolve to this day. The purpose of this article is to trace some of the important discoveries, and the people responsible for them, that have led to the modern concept of tissue perfusion.

ANATOMIC ERA

The concept of perfusion is one that has developed over centuries rather than the relatively brief time frame of scientific discoveries, such as DNA (Table 1). For millennia, there was no formal and systematic concept of the inner workings of the body. In order for the concept of tissue perfusion to reach its current state, a basic understanding of the functional anatomy, and circulation in particular, of the human body was needed.

Evidence exists that ancient humans had a basic understanding of the circulatory system. In a review of the early history of the circulatory system, Garrison¹ points out that cave paintings show the importance of striking the heart in ending the life of wild game. Garrison also notes that early man recognized that compressing the carotids led to a loss of consciousness and that staunching the flow of blood was key in preventing death from wounds on the battlefield.¹ He also notes that certain cultures recognized that the beating heart of a sacrificial victim embodied the life of the victim being sacrificed to the gods. Yet, even with this knowledge of what has been termed, *anatomic instinct*,¹ the anatomy and physiology of the circulatory system took centuries to understand, formalize, and elucidate.

The understanding of which organs were involved in circulation and how they were connected stymied early thinkers. For much of the time that man has walked the Earth, there was neither time nor excess resources to devote to formalized scientific inquiry. With the development of more complex cultures, time and resources became available to expend on scientific inquiries beyond the focus on basic subsistence. Art, music, and science all began to grow and develop. Early scientific understandings of the circulatory system begin to appear in this time frame (1000–500 BC). Although many historians of medicine point to the Greek system as the foundation of modern circulation, with Hippocrates the most recognized early source,² similar developments were occurring in other advancing societies at the time. Some researchers point to early Chinese texts as the earliest written evidence of the concept of circulation of

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