

Research Article

Historical Evolution of Vascular Access: From Antiquity to Modern Medical Practice

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Abstract

Introduction: Vascular access is a fundamental component of modern medical practice, enabling the administration of therapeutic agents and the implementation of specialized interventions. Its evolution reflects advances in medical knowledge and biomedical technology.

Aim: This descriptive review aims to systematically present the historical evolution of vascular access from antiquity to the present. It also seeks to identify key milestones that have contributed to the development of contemporary clinical applications.

Material and methods: A descriptive literature review was conducted using electronic databases, including PubMed, Scopus, and Google Scholar. The search included keywords such as "vascular access," "intravenous therapy," "history of medicine," and "hemodialysis," covering the period up to 2025. Studies published in English and Greek were included based on relevance to the topic, while non-scientific or low-quality sources were excluded.

Results: The review highlights the progressive understanding of the circulatory system from antiquity through the Renaissance, as well as major advances in the 19th and 20th centuries. Key developments include intravenous techniques, central venous catheterization, vascular access for hemodialysis, and parenteral nutrition.

Conclusion: The evolution of vascular access has played a critical role in improving healthcare delivery. Awareness of its historical development enhances clinical practice and supports the advancement of safer and more effective techniques.

More Information

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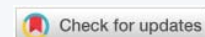
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Keywords: Hemodialysis; History of medicine; Parenteral nutrition; Vascular access; Venous catheters



Introduction

Vascular access is a fundamental component of modern clinical practice, since it provides direct and reliable access to the vascular system for the administration of pharmaceutical agents, fluids, blood products, parenteral nutrition as well as applying specialized treatment approaches such as hemodialysis and endovascular therapy [1,2]. The significance of vascular access becomes rather obvious in demanding environments, as the ICUs, Operating Theatre and Emergency Rooms.

Despite current technological evolution, vascular access is the product of a long and multidimensional historic course, which reflects the progressive advantage of medical knowledge, biomedical technology and scientific methodology [3]. Understanding how blood circulates, developing safe techniques to access vascular system and minimizing complications, constitute fundamental pillars of this evolution.

Reviewing vascular access is not limited only in documenting facts, it rather emphasizes the dynamic between theory and clinical practice. In addition, it highlights the



factors that accelerated or decelerated scientific progress, such as sociopolitical point of views, religious dogmas and technological restrictions.

Methods

A review of the available bibliography was performed in Pubmed, Scopus and Google Scholar. The keywords that were used are <<vascular access>>, <<intravenous therapy>>, <<history of medicine>>, <<hemodialysis>> and <<central venous catheterization>>.

Literature search and study selection

The electronic search identified 114 records from the selected databases (PubMed: 39, Scopus: 42, and Google Scholar: 33). After the removal of duplicate records, 89 publications remained for title and abstract screening. Forty-three articles were excluded because they were not directly related to the historical development of vascular access or lacked sufficient scientific relevance. The full texts of 46 publications were assessed for eligibility. Finally, 22 references that provided the most representative, reliable, and historically relevant information were included in the present narrative review.

The search covered the period between ancient times and 2025. Bibliographic sources of this review resulted after evaluating title, abstract and full text when necessary, of the retrieved articles. Our target was to include the most representative and reliable ones. Scientific papers and book chapters in English and Greek language that are highly related with the subject of the study were included, whereas undocumented sources and studies with limited relevance were excluded.

Results

Early perceptions around vascular access

i) Ancient Egypt: First documented perceptions about vascular system are spotted in Ebers Papyrus (around 1550 B.C.), one of the most significant medical scripts of ancient era [4]. Egyptians described an extensive vascular network initiating in heart and extending throughout the body, carrying not only blood but other <<vital substances>>.

Heart was considered the center of life, thoughts and feelings, a consideration that underlines the close connection between medicine and religious worldview. In spite of the absence of anatomical verification, the observation of the heartbeat as a health index, is a notable early clinical practice.

What is momentous about this era, is not the precision of the theories, but the foundation of the idea that there is a transportation system inside the human body, that was a prerequisite for future scientific developments.

ii) Ancient Greece: Ancient Greek medicine marked

a decisive transition from metaphysical interpretations to systematic observation and logical analysis. Hippocrates grounded medicine as a science, introducing the concept of the natural causation of diseases.

Praxagoras was one of the first to distinguish arteries from veins, even though he assumed that arteries carried air. Herophilus proceeded to more detailed anatomical descriptions, while Erasistratus developed theories about the function of the heart and vessels, although without a complete understanding of blood circulation.

This period is characterized by the consolidation of anatomical and physiological thinking, which formed the foundation for the development of more complex medical interventions (Aird, 2011).

iii) The dominance of Galen: Galen dominated medical thought for more than 13 centuries, forming a comprehensive but partly flawed theoretical system. He claimed that blood is produced by the liver, distributed and consumed in tissues, whereas heart had a secondary role [5].

Galen's contribution lies in the systematic organization of medical knowledge and the development of experimental approaches (mainly on animals). However, the absolute acceptance of his theories as undoubted truth, led to a significant slowdown in scientific progress.

Medieval period

During the Middle Ages, scientific progress in Europe was severely limited by the ascendancy of theology and the prohibition of autopsies. The lack of direct observation of the human body hindered the development of anatomy and physiology.

However, major progress took place in the Islamic world. Ibn al-Nafis described the pulmonary circulation with remarkable accuracy, indirectly challenging Galen. Despite the worth of the discovery, its limited dissemination in the West delayed its exploitation [6].

Renaissance and revolution in knowledge

Renaissance was a turning point for medical science, as it marked the reinstatement of direct observation and the experimental method as basic tools of knowledge. Gradual removal of restrictions on autopsies, allowed a more precise study of human anatomy, leading to questioning established dogmas.

Andreas Vesalius' contribution has been crucial, since his work elucidated the inaccuracies of Galen's theories and established anatomy as an empirical science [7]. This shift from authority to observation formed the foundation for the development of interventional techniques, including vascular access.

William Harvey's work was a defining milestone. He proved experimentally that blood circulates in a closed system and that heart functions as a pump. This awareness was far more than theoretically important, as it provided the environment to safely access the vascular system [5,7].

This period clearly demonstrates that progress in medical practice is inextricably linked to the development of basic science, especially anatomy and physiology.

Early endovascular treatment

It was during 17th century that the first systematic attempts to administer substances intravenously were performed. Christopher Wren's experiments and the studies of Richard Lower and other researchers, paved the way for the usage of vascular access as a therapeutic tool [8].

However, the absence of basic knowledge around physiology of blood and the scarcity of appropriate equipment, led to elevated rates of complications. Early blood transfusions, often between different species, caused unexpected and often lethal results.

This period is characterized by intense scientific enthusiasm and lack of systemic methodology. This temporary abandonment of endovascular practices, underlines the value of evidence based knowledge and safety in medical innovation.

Advances in 19th century

19th century was a critical period for turning from experimenting to structured and secure application of vascular access. More specific, it was the onset for the following clinical techniques:

- **Blood transfusions.** James Bludell's research resulted in first successful transfusions from human to human, setting the foundation for modern blood transfusion. This practice highlighted the importance of compatibility, which was fully understood only in the next century when blood types were discovered [9].
- **Endovascular fluid administration.** Cholera epidemics were a powerful catalyst for the development of intravenous therapy. O' Shaughnessy and Latta introduced administration of electrolyte solutions to treat severe dehydration, achieving a significant reduction in mortality [3].
- **Antisepsis and asepsis.** The inception of antiseptic techniques by Joseph Lister, commanded a revolution in surgery and interventional techniques. The reduction of infections permitted a wider and more protected vascular puncturing [10,11].

Overall, 19th century signals the transition from hazardous and empirical practice to a safer, substantiated and reproducible clinical process.

Technological advances in 20th century

20th century was portrayed by rapid progress in both basic science and biomedical technology, which led to a radical transformation of vascular access.

- I. **Discovery of blood types.** The discovery of blood groups by Karl Landsteiner in 1901 laid the foundation for the safe application of transfusions, dramatically reducing immune reactions and mortality [12].
- II. **Development of materials and equipment.** The introduction of plastic and biocompatible materials led to the construction of flexible, durable and safe catheters. The ability to produce disposable equipment lessened the threat of infections and enhanced the quality of care [1].
- III. **Central venous catheters.** The development of the Seldinger technique was a major innovation, enabling safe placement of catheters in central veins. This considerably expanded the therapeutic options, especially in critically ill patients [6].

This era represents the transition to a high level of technological specialization, with a parallel increase in the need for educating and training health care professionals. The choice between peripheral, midline and central catheters is now based on formalized standards related to the duration of treatment and patient characteristics [13].

Specialized applications of vascular access

- **Hemodialysis.** Developing dependable vascular access was a key prerequisite for the establishment of hemodialysis as a treatment for chronic renal failure. Also, the introduction of arteriovenous fistulas allowed long-term and repeated access to the vascular system, significantly improving patient survival [14].
- **Parenteral nutrition.** The development of total parenteral nutrition allowed the administration of nutrition in patients with non-functional gastrointestinal system. This application highlighted the importance of long-term and safe venous access, particularly through central catheters [15].

These usages emphasize the transition of vascular access from a simple technical means to a critical therapeutic tool.

Current advances and trends

- **Biocompatible materials.** The usage of advanced materials, such as polyurethane and silicone, has substantially upgraded the biocompatibility of catheters, reducing thrombotic and infectious complications [2].
- **Imaging guidance.** The widespread utilization of



ultrasound guidance has improved success rates and decreased complications during catheter placement, establishing the procedure as a safe and trustworthy one [16,17].

- **Minimally invasive techniques.** Modern direction in medicine aims at abating trauma and complications, via developing less invasive techniques and refining procedures.

At the same time, rising emphasis is placed on the education of nursing staff, who play a critical role in the management of vascular access and the prevention of complications [18].

Complications and nursing management

In spite of great technological progress, complications of vascular access remain frequent, with the peripheral venous catheters failures being documented at elevated levels globally [19,20]. Leading complications include phlebitis, extravasation and catheter occlusion.

Up to date nursing practice prioritizes the prevention of these complications by utilizing the application of appropriate stabilization techniques, adherence to antisepsis protocols, and regular assessment of vascular access [21,22].

Embodying evidence based guidelines in everyday practice, remains key element for augmenting patient safety and reducing hospital expenses.

Discussion

The evolution of vascular access techniques on the whole, as presented in Table 1, reflects the transition from empirical practices to evidence based, safe and technologically supported clinical application.

Comparing to international data

The findings of the present review are consistent with the international literature, which emphasizes the importance of

vascular access as a key element in enhancing survival and quality of care.

Several published studies have addressed specific aspects of the historical evolution of vascular access. Rivera, et al. emphasized the development of peripheral intravenous catheters and their contribution to modern infusion therapy, while Nossaman, et al. highlighted the historical milestones that led to contemporary cardiac catheterization techniques. Similarly, Aird described the transition from Galenic concepts to Harvey’s revolutionary understanding of blood circulation, and Ducasse, et al. presented the evolution of vascular access from a surgical perspective. The present review is consistent with these reports but differs by providing an integrated historical overview that combines anatomical discoveries, technological innovations, hemodialysis access, parenteral nutrition, and contemporary vascular access practices within a single narrative framework.

The evolvement of vascular access over the time, reflect the total progress of medical science, spotlighting how close is the interaction between theoretical knowledge, technological innovation and clinical application. The route from early philosophical an empirical perceptions of antiquity, to current evidence based practices, had been characterized by gradual but decisive progress [3].

The development of anatomy and physiology had a determining impact on this evolution, mainly during Renaissance, when systematic observation and experimental method led to understanding blood circulation. Harvey’s contribution was a turning point, as it provided the scientific basis for safe intervention in the vascular system [5,7].

Furthermore, progress in vascular access would not have been possible without technological advancements and the launching of innovative materials and techniques. The development of biocompatible catheters, the application of the Seldinger technique, and the use of image guidance greatly

Table 1: Main milestones in the historical evolution of vascular access from antiquity to modern times.			
Era	Milestone	Main representatives	Scientific significance
Ancient Egypt (≈1550 B.C.)	Early perceptions around vascular system (Ebers Papyrus)	-	Introduction of the idea of a vascular network and the value of pulse
Ancient Greece	Distinction between arteries and veins, foundation of medical way of thinking	Hippocrates, Praxagoras, Herophilus, Erasistratus	Foundation of anatomical and physiological approach
Roman period	Dominance of the Galenic model	Galen	Systematization of knowledge, but also inhibition of progress
Middle Ages	Description of pulmonary circulation	Ibn al-Nafis	Early questioning of Galen’s theories
Renaissance	Anatomical revolution	Vesalius	Establishment of empirical anatomy
17 th century	Discovery of blood circulation	William Harvey	Foundation for interventions in vascular system
17 th century	Early intravenous therapy	Wren, Lower	Initiation of intravenous interventions
19 th century	Blood transfusions	Blundell	Development of blood donation
19 th century	Endovascular fluids (cholera)	Latta	Foundation of endovascular therapy
19 th century	Antisepsis	Lister	Reduction of infections
20 th century	Blood groups	Landsteiner	Safe transfusions
20 th century	Seldinger’s technique	-	Safe venous catheterization
20 th century	Catheters development	-	Improvement of clinical practice
Modern times	Ultrasound guidance, biocompatible materials	-	Safety and precision

facilitated the improvement of the safety and effectiveness of interventions [2,6,16].

A pivotal moment was the introduction of asepsis and antisepsis that permitted a dramatic decrease of infections and the broadening of interventional capabilities. Lister's input under this direction has been elucidating for shifting towards safer clinical practices [10].

Despite major progress, vascular access complications remain a challenge in modern clinical practice. High failure rates of peripheral venous catheters and relevant complications, accent the need for continued education of healthcare professionals and strict implementation of evidence-based guidelines [19,20,21].

Finally, the modern approach to vascular access increasingly focuses on individualizing care, taking into account the unique characteristics of each patient and the needs of their treatment. Selecting the appropriate catheter type, correct placement technique and the continuous assessment of the access are critical factors for improving clinical outcomes [13].

To sum up, the evolution of vascular access validates that progress in medicine depends on the combined development of scientific knowledge, technological innovation, and clinical experience. Understanding this dynamic relationship is essential for perpetually improving the quality of care and enhancing patient safety.

In contemporary clinical practice, vascular access is closely associated with the management of a broad spectrum of vascular disorders. Conditions such as peripheral artery disease, aneurysms, and deep vein thrombosis increasingly benefit from minimally invasive endovascular approaches, including angioplasty, stent placement, catheter-directed thrombolysis, and image-guided interventions. These developments demonstrate how advances in vascular access have contributed not only to supportive therapies but also to the expansion of modern vascular medicine and surgery.

Limitations

This review presents some limitations. First, it follows a narrative rather than a systematic review methodology, which may increase the risk of selection bias. Moreover, the historical nature of the available literature results in substantial heterogeneity regarding study design, methodology, and reporting standards. Finally, some historical information is derived from secondary sources, which may affect the completeness and accuracy of certain historical interpretations.

Suggestion for further investigation

Future studies should focus on the systematic evaluation of modern vascular access techniques, as well as the development of innovative technologies that will further reduce complications.

Conclusion

The historical evolution of vascular access illustrates the close interaction between scientific knowledge, technological innovation, and clinical practice. From the early, empirical concepts of antiquity to contemporary highly precise techniques, progress has been gradual yet transformative, significantly improving patient outcomes and healthcare delivery.

Understanding this historical progression provides valuable insight into the foundation of current vascular access practices and reinforces the importance of evidence-based clinical decision-making. In particular, health care professionals involved in vascular access management can benefit from recognizing the scientific and technological milestones that have shaped modern standards of care.

Future developments are expected to focus on advanced biomaterials, infection- prevention technologies, artificial intelligence-assisted vascular assessment, and personalized vascular access strategies. Continued education, research, and technological innovation will remain essential for improving patient safety and optimizing clinical outcomes.

Researchers' contribution

The researchers jointly participated in the conception and design of the study, data collection, and writing of the text. All authors critically evaluated the article and approved the submission of the final text.

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