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Review

Between the lines: The 50th anniversary of long-term central venous catheters

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ABSTRACT

Background: Tunneled central venous catheters (CVC) were developed five decades ago. Since then, several clinician-inventors have created a variety of catheters with different functions. Indeed, many catheters have been named after their inventor. Many have wondered who the inventors were of each catheter, and what specifically inspired their inventions. Many of these compelling stories have yet to be told.

Data source: A literature review of common catheters and personal communication with inventors. Only first person accounts from inventors or those close to the invention were used.

Conclusions: CVCs are now essential devices that have saved countless lives. Though the inventors have earned the honor of naming their catheters, it may be reasonable to consider more consistent terminology to describe these catheters to avoid confusion.

Introduction

The tunneled central venous catheter (CVC) celebrates its 50th anniversary in 2017. It goes without saying that the tunneled CVC has been one of the most crucial important advances in medicine in our lifetime. After the first catheter was created and the concept of long-term central venous access was accepted, many modifications to the catheter have lead to additional uses which have benefited innumerable patients with life-saving therapy, including chemotherapy, bone marrow transplantation, and hemodialysis amongst countless other uses (Fig. 1). While these catheters are all considered commonplace now, their design and usage have evolved over several generations of practitioners. Added to this, many catheters have been named after the original inventor of the device. As a result, an entire generation has passed which may have little to no knowledge of the difference between these common but differently named catheters. This review aims to answer commonly asked questions and to clarify misconceptions about tunneled CVCs, from personal accounts of the inventors themselves (Table 1).

How did we get to this point and why would one need a central line?

Although fascination with human blood probably began with the first human, the story of vascular access must properly begin with bloodletting which is described in ancient Egyptian and Arabic texts; the Old Testament contains veiled references to blood transfusion,[1] but it remained for **William Harvey** and his students to begin scientific investigations of blood volume and blood pressure. These studies depended on crude metal tubes used as cannulae.[2,3] Several reports of blood transfusion appeared in the early 1600s with results ranging from “no ill effect” to “very effective.” **Robert Boyle** and **Sir Christopher Wren** introduced more sophisticated cannulae crafted from the quill of a bird's feather[1,4,5] and by the late 1600s they had performed animal experiments involving the injection of intravenous narcotics, and the popular press was publishing reports (and cartoons) detailing animal-to-human blood transfusion. By 1697, religious and secular opposition to the practice of “xeno-transfusion” culminated in a ban on all transfusion for most of Europe. Bloodletting, however, continued to flourish. In 1733, **Stephen Hales**, an English clergyman, described experiments on animal physiology including

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[1] Financial disclosure – has been a consultant for Bard.

[2] Please note that the original draft was composed by David Tapper and Robert O. Hickman. David Tapper passed away in 2002 prior to the update but due to his key contribution to this review article, he is posthumously listed as one of the authors to give him the appropriate credit.

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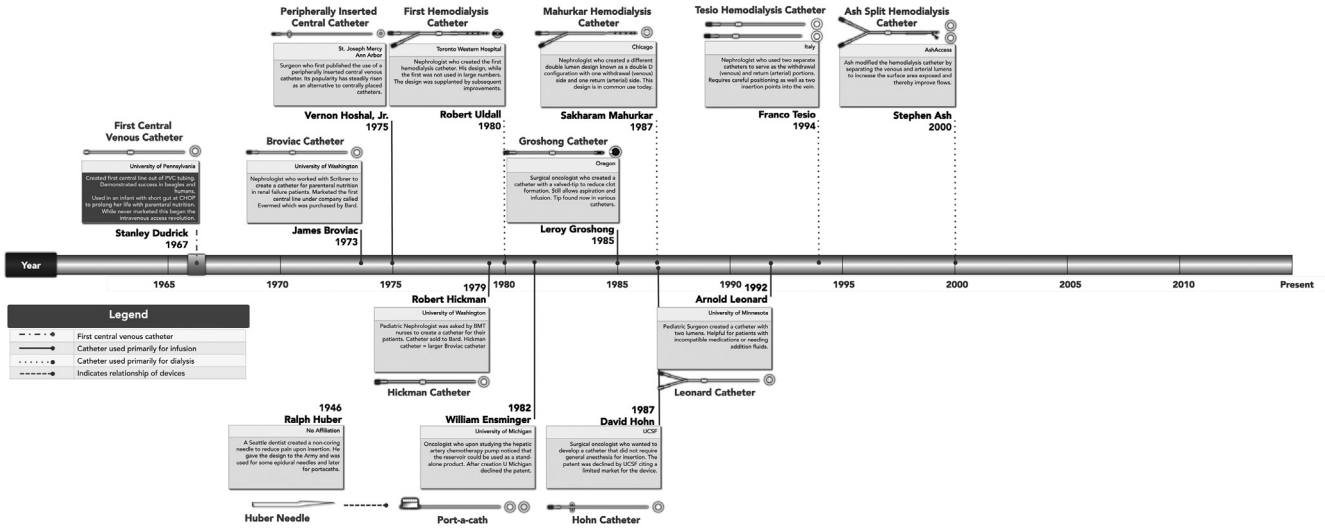

Fig. 1. A timeline indicating when each tunneled central venous catheter was developed and the inventor.

Table 1
Common commercial long term central venous catheters.

Type of Catheter	Inventor(s)	Main use	Key distinguishing feature
Broviac	Beldig H Scribner, Robert C. Atkins, John W. Broviac	Fluid administration, hyperalimentation, chemotherapy, infusion therapy	Tunneled catheter held into the tract by a fabric cuff.
Hickman	Robert O. Hickman, James R. Sisley	Fluid administration, hyperalimentation, chemotherapy, infusion therapy	Similar to a Broviac but larger in size
Groshong	LeRoy E Groshong, Ronald J. Brawn	Fluid administration, hyperalimentation, chemotherapy, infusion therapy	Valved tip to reduce clot formation
Leonard	Arnold S. Leonard	Fluid administration, hyperalimentation, chemotherapy, infusion therapy	Double lumen catheter allowing administration of incompatible solutions simultaneously
Implantable venous access port	William D. Ensminger, Elton M. Tucker, John E. Niederhuber	Chemotherapy, infusion therapy	Subcutaneous port allows easier daily management for patients
Hemodialysis	Sakharam D. Mahurkar, Geoffrey Martin	Hemodialysis, Pheresis	Able to achieve high flows for withdrawal and reinfusion
Split Hemodialysis	Stephen R. Ash, Tim Schweikert	Hemodialysis, Pheresis	Separate tips have more side holes to increase flow rates
Hohn	David C. Hohn	Fluid administration, hyperalimentation, chemotherapy, infusion therapy	Does not require tunneling; inserted into central veins
Peripherally inserted central catheter	Verne L. Hoshal Jr.	Fluid administration, hyperalimentation, chemotherapy, infusion therapy	Does not require tunneling; inserted into peripheral veins

measurements of the “force of blood” which essentially were the first descriptions of blood pressure.[3,6] It would be another 150 years before observations and studies on the massive fluid and electrolyte losses of cholera patients stimulated the investigation of intravenous fluid therapy. In 1831, **William O'Shaughnessy** coined the term “black blood” to describe the result of severe physiologic salt and water depletion.[5,7] **Thomas Latta** used the pandemic of cholera in the 1880s to demonstrate that fluid replacement was the necessary and sufficient treatment, concluding that “one third of is moribund patients were restored to the world”.[5,8]

Intravenous infusion therapy was still not universally accepted in the 1800s, perhaps due to well-meaning but ill-fated infusions of non-sterile water, cow's milk, albumin, and various salt concentrations.[9] One can imagine a significant mortality rate from such interventions related to infection, air embolus, hemolysis, hyponatremia, and anaphylaxis. However, as early as 1885, the French physiologist **Claude Bernard** was performing sophisticated studies of cardiac catheterization in animals,[5] later describing myocardial perforation as its first complication. The same era saw the development of the first “hypodermic” needle and syringe. In the early 1900s **Karl Lansteiner** described the ABO system of blood types; sodium citrate was introduced as an anti-coagulant; and sterile needles, tubing, and continuous intravenous fluid infusions became commonplace. Soon thereafter, the “catheter through the needle” became the first long-term intravenous device, followed by the safer, more comfortable, and more durable “cannula over the needle”.[5]

However, all of the aforementioned experimentation was via peripheral vascular access, which provided adequate entry of substances into the body for short periods of time. Administration of long-term (>6 weeks) therapy was more challenging due to the limited number of peripheral veins, and the risks of phlebitis, thrombosis, and pain. This gave rise to an interest in use of central veins — veins in close proximity to the heart — because it was suspected that central veins might better tolerate the administration of substances which otherwise might irritate peripheral veins. Central veins are marked by a more rapid dilution of administered fluid or drugs due to higher blood flow in the superior and inferior cava, and in the heart itself. The challenge was in how to place and maintain a long-term catheter successfully into these vessels.

Who created the first central line?

Stanley J. Dudrick is the first individual to have described the concept and the steps involved in the creation of what today is considered a standard tunneled CVC.[10] The problem he was given at