



## The staggered legacy of giants. The greatness of the pulmonary flotation catheter

El legado escalonado de gigantes. La grandeza del catéter de flotación pulmonar

*O legado escalonado de gigantes. A grandeza do cateter de flutuação pulmonar*

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*Human medical experiments which are life-threatening should not be performed unless the primary investigator himself is subjected to the experiment.*

Nüremberg codex on medical research of (1947)

The centenary of the report «Die sondierung des rechten herzens» (the catheterization of the right heart), the first right catheterization medical paper by the German doctor Warner Theodor Otto Forssmann is near, a fact not only significant for modern medicine but also of great courage for having practiced it himself; his emotion is imaginable when he observed radiologically the tip of the recently inserted 60 cm long urinary catheter through his anterior cubital vein advance through his own right atrium, feeling in his own words a progressive painless warmth as the tube moved along. Sometime before in 1912 another German, Dr. Fritz Bleichroeder, experimented by inserting catheters into the veins and arteries of animals and people, but apparently without the intention of reaching the right heart.

It was more than 25 years later that after World War II, that the French-American André Frédéric Cournand and the American Dickinson Woodruff Richards Jr. developed in New York a catheter that was able to advance to the pulmonary artery, moving the technique forward towards clinical application, with two direct products: the knowledge of hemodynamics in different types of chronic and acute heart diseases and second, the winning together with Forssmann, of the Nobel Prize in Physiology and Medicine in December 1956.

And although in 1964 the British doctor Ron D Bradley of the St. Thomas's Hospital School, in London developed miniature catheters and published in the Lancet their use for diagnostic purposes in the critically ill patient, H. Jeremy C. Swan, an Irish immigrant in the United States, and the Czech doctor William (Villem) Ganz cardiologists at Cedars Sinai Hospital in Los

Angeles, are generally considered the fathers of the pulmonary artery catheter, usually called the Swan Ganz catheter (nicknamed simply «the swan» in Mexico), to which an inflatable balloon was added at the tip inspired by the simple observation of the movement of sailing boats in the bay of Santa Monica.

The logic of physics suggested that blood flow would be sufficient to advance, said this flexible catheter with its inflated air balloon through the right chambers of the heart and into the pulmonary circulation until it became wedged.

In this way, it was possible to measure the pressures in the right circuit, from the right atrium, passing through the right ventricle and the systolic, diastolic and mean pulmonary artery pressures, up to the wedge pressure, the pulmonary capillary pressure, that allowed estimating the pressure in the left atrium. It is not exactly that until now these measurements could not be made; but the catheters used at those years were rigid, which made the procedure complex and with a high rate of complications, being another plus the advancement of the catheter through the interpretation of the pressure curves, without the need of a fluoroscope, enabling physicians for the first time to accurately measure the performance of the heart at the bedside, triggering dramatic changes in the medical management of critically ill patients all over the world; a phenomenon in the contemporary history of medicine.

Shortly thereafter in 1968, Ganz developed the thermodilution method by adding a thermistor and a third lumen to inject cold saline into the right atrium; which allowed adding the measurement of the pulmonary pressures to the measurement of the flow, and therefore to calculate the systemic and pulmonary vascular resistance and eventually the cardiac output. His 1970 article in the New England Journal of Medicine is a classic. Eventually new capabilities were added such as determining the oxygen saturation in the right heart chambers, the right ventricle ejection fraction, the continuous measurement of cardiac output in real time, not to mention heparin bonded catheters and the possibility of simultaneous multidrug treatment through a secure central catheter.

Unfortunately, its widespread use in the critically ill patient was exaggerated worldwide, leading to a clear

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over indication; in some centers it was routinely placed in all major surgery regardless of the level of risk, in such a way that despite its usefulness, advantages and benefits, detractors and reports of complications soon emerged, especially at the hands of non-expert users or with insufficient training with its application. In some cases, their permanence in the pulmonary circulation was probably unreasonably prolonged for many days, since it gave clinicians a feeling of control. Routines in ICUs aren't always smart, and prospective randomized trials have reported that in many clinical circumstances, the routine use of balloon flotation catheters is not indicated at all.

In particular, the propensity analysis study of Gore et al. published in *Chest* in 1987 marked a turning point in the abandonment of invasive hemodynamic monitoring in critically ill patients by reporting a significant higher mortality in the group of cardiac patients followed up with this type of monitoring, a result with a complex explanation, since apparently it was not a consequence of the selection of more severe patients in worst clinical condition and an urgent need of hemodynamic monitoring.

Mortality is not a lucky outcome when applied to diagnostic methods, the Swan Ganz is not a treatment tool, and as always in monitoring, the most important thing is to know what needs to be monitored and the correct interpretation of the obtained data. In general, many of the routines in medicine lack good support and scientific evidence.

Since then, different clinical studies have emerged with either a lack of evidence of harm or benefit with the Swan Ganz catheter use in the critically ill patient or reporting a greater number of complications, including pulmonary venous thromboembolism and pulmonary infarction.

However, we have to appreciate that the pulmonary flotation catheter has given us a lot of pathophysiological knowledge and a better understanding of the natural history of the disease and response to different therapeutic interventions, having contributed to an advance in medicine and notably contributing to make the foundations of the nascent specialty of critical care medicine more solid and even until now despite the advances in non-invasive forms of imaging and monitoring, continues to be valuable in selected cases in general, perhaps in the most serious and complex in the ICU, cardiogenic shock and complications of heart failure, also during the workup for heart, lung, and heart and lung transplantation, as well as in the diagnostic approach to pulmonary hypertension; where it is a mainstay for assessment and characterization, a true gold standard of many heart, lung and systemic

conditions that orbit around this entity. In special cases, it may also be indicated in the preoperative assessment of patients in the liver transplant program.

It is also useful in the assessment of coronary disease, and at the level of the pulmonary physiology laboratory in the advanced evaluation of exercise tests in particularly complex and exceptional cases. The control against which the new technology around hemodynamic monitoring is compared and validated continues to be the pulmonary flotation catheter, which reveals the most reliable and exact hemodynamic information in practice. Appropriate specialized training in the area of hemodynamics has been made possible in part by the Swan Ganz catheter.

I vividly remember the afternoon when, as an undergraduate intern, I had the opportunity to observe for the first time a right catheterization in a seriously ill patient by Dr. Eulo Lupi Herrera, Head of the INCICH Cardiopulmonology Service and assisted by Dr. Julio Sandoval Zárate, a third-year critical care resident at that time. I was only in charge of seeing that the graph paper of the bulky VR6 ran properly to document the pressure traces; probably as a consequence of this learning and with the personal bias of being an intensivist and a pulmonologist, I feel more comfortable performing a scheduled right heart catheterization in the ICU, with everything it can offer, than in a conventional catheterization room.

From the years of my residency, I still have my copy of the essential book on the pulmonary artery catheter from the early eighties, edited by Charles L Sprung, a mandatory reading at that time and that in little more than 200 pages revealed to us what every intensivist was supposed to know about the hemodynamics of the critically ill patient as hemodynamic monitoring expanded so rapidly in their application over those years.

The importance of hemodynamic monitoring is such that COMMEC organized for years a very active hemodynamic monitoring chapter with positioning, education and research activities.

In conclusion although invasive, the Swan Ganz catheter will continue to be a pillar in the monitoring of critically ill patients and a standard in the study of pulmonary hypertension, so every intensivist must have a broad and sufficient knowledge of its use and application, as well as be familiar with the correct interpretation of the hemodynamic data obtained from it, countless particularly seriously ill patients will surely benefit from these skills and knowledge.

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