

# Use of the Miniature Pressure-Wire Manometric System in Congenital and Acquired Structural Heart Diseases

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## ABSTRACT

**Background:** Historically, intravascular pressure recording has contributed to the development of interventional cardiology. Although new imaging resources have gained much attention, accurate intravascular pressure measurement remains essential for the diagnosis and evaluation of interventional therapy methods. We describe the use of the miniature manometric system (pressure-wire) to obtain pressure curves in congenital and acquired structural heart diseases. **Methods:** The Radi Analyzer<sup>®</sup> Xpress (St. Jude Medical Inc., St. Paul, MN, USA) and PressureWire<sup>®</sup> Certus systems were used in procedures with 5 F catheters under general anesthesia and ventilatory support in children. Manometric tracings were obtained simultaneously from pressure-wire and the 5 F catheter in patients whose therapy strategies were dependent on the analysis of intravascular pressures, and in whom it was not possible to obtain them accurately by conventional methods. **Results:** Pressure-wire was used to obtain pulmonary intravascular pressures in patients with systemic-pulmonary collaterals with or without angiographically detected stenosis, and with different structural heart diseases, in the evaluation of pulmonary branch stenosis, in the localization of surgical conduit stenosis (e.g. after Rastelli surgery), surgical shunts (such as Blalock-Taussig) and in the preoperative evaluation of cavopulmonary shunts. The procedure was performed safely, and manometric tracings were obtained with an adequate quality. **Conclusions:** The miniature manometric system is well accepted as a complementary diagnostic modality for the functional assessment of coronary lesions in interventional cardiology. It is also a complementary diagnostic method in different structural, congenital and acquired heart diseases.

**DESCRIPTORS:** Heart defects, congenital. Cardiac catheterization. Hemodynamics.

## RESUMO

### Uso do Sistema Manométrico Miniaturizado Pressure-Wire em Cardiopatias Estruturais Congênitas e Adquiridas

**Introdução:** Historicamente, o registro de pressões intravasculares contribuiu para o desenvolvimento da cardiologia intervencionista. Embora atualmente novos recursos de imagem sejam preponderantes, a medida acurada de pressões intravasculares ainda é essencial em muitos contextos diagnósticos e de aferição de métodos terapêuticos intervencionistas. Descrevemos a utilização do sistema manométrico miniaturizado (*pressure-wire*) para obtenção de curvas pressóricas em cardiopatias estruturais congênitas e adquiridas. **Métodos:** Foram utilizados os sistemas Radi Analyzer<sup>®</sup> Xpress (St. Jude Medical Inc., St. Paul, Minnesota, Estados Unidos) e PressureWire<sup>®</sup> Certus durante procedimentos com cateteres diagnósticos 5 F realizados sob anestesia geral e suporte ventilatório em crianças. Traçados manométricos foram obtidos simultaneamente com o *pressure-wire* e o cateter 5 F em pacientes para os quais era imperativa a decisão terapêutica com base em análise das pressões intravasculares e nos quais não era possível obtê-las acuradamente pelos métodos convencionais. **Resultados:** O *pressure-wire* foi utilizado para obtenção de pressões intravasculares pulmonares em pacientes com colaterais sistêmico-pulmonares, com estenoses angiográficas ou não, e com variadas cardiopatias estruturais, na avaliação de estenoses de ramos pulmonares, na localização de estenoses de condutos cirúrgicos (por exemplo: após cirurgia de Rastelli), *shunts* cirúrgicos (como o de Blalock-Taussig) e na avaliação pré-operatória de derivações cavo pulmonares. O procedimento foi realizado com segurança, tendo sido obtidos traçados manométricos com qualidade adequada. **Conclusões:** O sistema manométrico miniaturizado está consagrado no cenário da cardiologia intervencionista, enquanto modalidade diagnóstica complementar para avaliação funcional de lesões coronárias. Esse sistema também constitui método diagnóstico complementar em diversas cardiopatias estruturais, congênitas e adquiridas.

**DESCRIPTORES:** Cardiopatias congênitas. Cateterismo cardíaco. Hemodinâmica.

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Received: 01/03/2014 • Accepted: 02/25/2014

The recording of pressure curves to explain the physical manifestations of the cardiovascular system was one of the key boosters for the development of modern hemodynamics, as applied to the study of human physiology and pathophysiology. The pioneering studies of Claude Bernard, cited by Buzzi in 1959,<sup>1</sup> led to the catheterization of cardiac chambers in 1847, with the blood pressure recording of the right ventricle (RV) in experimental animals.

In a little less than a century later, following the self-experience of Forssman in 1929, the subsequent work of André Cournand and several other researchers decisively boosted the knowledge of the pathophysiology of congenital and acquired diseases by means of pressure records and manometry of the right heart chamber and pulmonary circulation. In parallel, methods of oximetry and analysis of dilution curves of several indicators were developed to measure cardiac output, and for the detection and quantification of leads or communications (shunts) between systemic and pulmonary circulations. Through the association of manometric data to these methods, it was possible to measure vascular resistances and also at the level of the heart valves, in normal conditions and in the presence of structural, congenital, and acquired cardiovascular defects.<sup>2,3</sup>

In more recent decades, there has been great interest in radiological contrast angiography and other methods of cardiovascular imaging during cardiac catheterization, such as intravascular ultrasound (IVUS) and optical coherence tomography. Unfortunately, the practical use of such technological advances has occurred simultaneously with a certain lack of interest, on the part of interventional cardiologists, in the classical methods of hemodynamics – including blood pressure records, blood flow measurements, and vascular and valve orifice resistance calculations.

In the case of congenital heart diseases, the determination of intravascular and cardiac chamber pressures is of particular importance, since they are defining factors for the modality of treatment to be followed, because these pressures influence the choice of surgical technique, occasionally contraindicating or conditioning the palliative therapy. In the scenario of some of these diseases, sometimes with a very reserved prognosis, the documentation of reliable hemodynamic data represents a fundamental aspect of diagnosis.

Manometry is conventionally performed by diagnostic catheters and systems for measuring pressure, based on a liquid column and an oscillometric diaphragm, which transmit the mechanical drive detected by the catheter tip, with its conversion into an electrical signal, which, in turn, is transduced into a graphic recording with electronic typing. This transduction system of physical signs is subject to artifacts that exacerbate and/or attenuate the output, resulting in erroneous pressure values, as they are inherently influenced and warped

by the dynamic frequency response of the system as a whole. As part of the relative neglect to which the method of manometry during cardiac catheterization is currently relegated, generally there is no attention given to a periodic verification of the ideal conditions of dynamic response of the intravascular pressure transduction system.

The miniaturized manometric method is a system for measuring intravascular pressure that adapts a pressure sensor directly to a 0.014, guide-wire, similar to those commonly used in coronary angioplasty, which allows for the recording of simultaneous and comparative pressure graphics between the device and the catheter-guide. Since 1996, from the clinical use by Pijls and De Bruyne in the functional evaluation of coronary stenoses, the method was consolidated in the practice of interventional cardiology in various applications related to the measurement of coronary fractional flow reserve and coronary vasodilator reserve.<sup>4</sup>

The purpose of this article was to describe the pioneering use, in this center, of the pressure-wire system in obtaining reliable pressure curves in patients with congenital and acquired structural heart diseases, when reliable manometric records of the pulmonary circulation, transvalvar gradients, and stenoses of surgical or native vascular conduits are needed.

## METHODS

### Description of devices

The description in this article refers to the RADI Analyzer® Xpress and PressureWire® Certus (St. Jude Medical Inc. – St. Paul, Minnesota, United States), systems in use in this interventional cardiology laboratory since 2007. In the modalities in which the authors have used these tools, the manometry devices are 0.014, guide-wires with floppy-type tip, similar to those used in coronary angioplasty, with a pressure sensor located at the junction between the more radiopaque distal end and the wire body, approximately 3 cm from the tip. The guides are constructed in the core-to-tip format, with a torque transmission at a nearly 1:1 ratio. In the domestic market, the hydrophilic PressureWire® Certus (Figure 1) is available.

The pressure-wire is connected to the RADI Analyzer® Xpress console for data transmission via an adapter at the proximal portion of the guide-wire. The system allows for the measurement of pressures between –30 and 300 mmHg, with an accuracy of  $\pm 1\%$  mmHg plus  $\pm 1\%$  of the values obtained between –30 and 50 mmHg; and of  $\pm 3\%$  of the values obtained between 5 and 300 mmHg. The response frequency of the system is 25 Hz, which allows obtaining a signal with high accuracy, even at high heart rates.

The RADI Analyzer® console has dimensions of 29 × 12 × 31.5 cm, weighs approximately 4.4 kg (with

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