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catéter de Swan-Ganz, monitorización de la arteria pulmonar, cateterismo cardíaco derecho, catéter pulmonar, hemodinámica, aplicación.

Mobile application to standardize and facilitate invasive hemodynamic calculations

Aplicación para estandarizar y facilitar cálculos hemodinámicos invasivos

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ABSTRACT

Invasive hemodynamic assessment is crucial in critical cardiac conditions but is frequently subject to calculation and conversion errors due to the use of fragmented methods. In the Android environment, there are general-purpose medical calculators, including some specifically designed for right heart catheterization. Here we present GIPOGO RHC Tools (Android), a clinical tool for right heart catheterization that uses device-managed authentication at the start of the session. These data may be used to generate graphs and reports. Data stored temporarily in memory are used solely to maintain the workflow continuity. The handling of measurement units for variables is based on maintaining canonical units, with centralized conversion decoupled from the user interface, enabling flexible visualization without the risk of double conversion. Invasive hemodynamics is particularly sensitive to errors in calculation, unit conversion, and traceability; relying on multiple independent online calculators can compromise reproducibility and the preservation of clinical context. Standardizing hemodynamic recording at the session level and over time can promote comparability across measurements, support continuous improvement in the quality of care, and potentially generate research data.

RESUMEN

La evaluación hemodinámica invasiva es indispensable en situaciones cardíacas críticas, pero a menudo está sujeta a errores de cálculo y conversión debido al uso de métodos discontinuos. En el entorno Android, existen calculadoras médicas de propósito general diseñadas específicamente para el cateterismo cardíaco derecho. Aquí presentamos GIPOGO RHC Tools (Android), una herramienta clínica para el cateterismo cardíaco derecho que utiliza la autenticación gestionada por el dispositivo al inicio de la sesión. Estos datos pueden emplearse para generar gráficos e informes. El almacenamiento temporal de datos en memoria se limita a mantener la continuidad operativa del flujo de trabajo. El manejo de las unidades de medida de las variables se basa en el uso de unidades canónicas, con una conversión centralizada e independiente de la interfaz de usuario, lo que permite una visualización flexible sin riesgo de doble conversión. La hemodinámica invasiva es especialmente sensible a errores de cálculo, de conversión de unidades y de trazabilidad; depender de múltiples calculadoras en línea independientes puede comprometer la reproducibilidad y la preservación del contexto clínico. Estandarizar el registro hemodinámico a nivel de sesión y a lo largo del tiempo puede favorecer la comparabilidad entre mediciones, apoyar la mejora continua de la calidad asistencial y, potencialmente, generar datos para la investigación.

INTRODUCTION

Invasive hemodynamic assessment is crucial in contexts such as pulmonary hypertension and cardiogenic shock. In daily practice, these calculations are often performed in a fragmented manner, using online calculators without continuity between measurements or traceability, especially when comparing serial

measurements, leading to frequent ambiguities in units. This combination increases the risk of calculation and conversion errors with clinical impact.

In the Android environment, there are general-purpose medical calculators (e.g., MDCalc, Medscape, or Calculate by QxMD) which include multiple formulas. However, in our recent practical review of the app

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store, few offer a tool specifically designed for right heart catheterization that allows recording of a session and preserves the context (inputs, units, and results), rather than relying on isolated calculators. We have also identified applications that provide invasive hemodynamic calculations (e.g., cardiac output by the Fick method, vascular resistances, and pulmonary artery pulsatility index), as well as tools that integrate them with cardiogenic shock monitoring functions.¹⁻³

As an example of this approach, we present GIPOGO RHC Tools (Android), a clinical tool for right heart catheterization, designed to standardize invasive hemodynamic calculations and preserve their traceability. The application is accessible via Google Play (<https://play.google.com/store/apps/details?id=com.gio.gipogo.rhctools>) and organizes information by patient and study session, allowing a specific hemodynamic session to be recorded with preserved inputs, units, and results, as

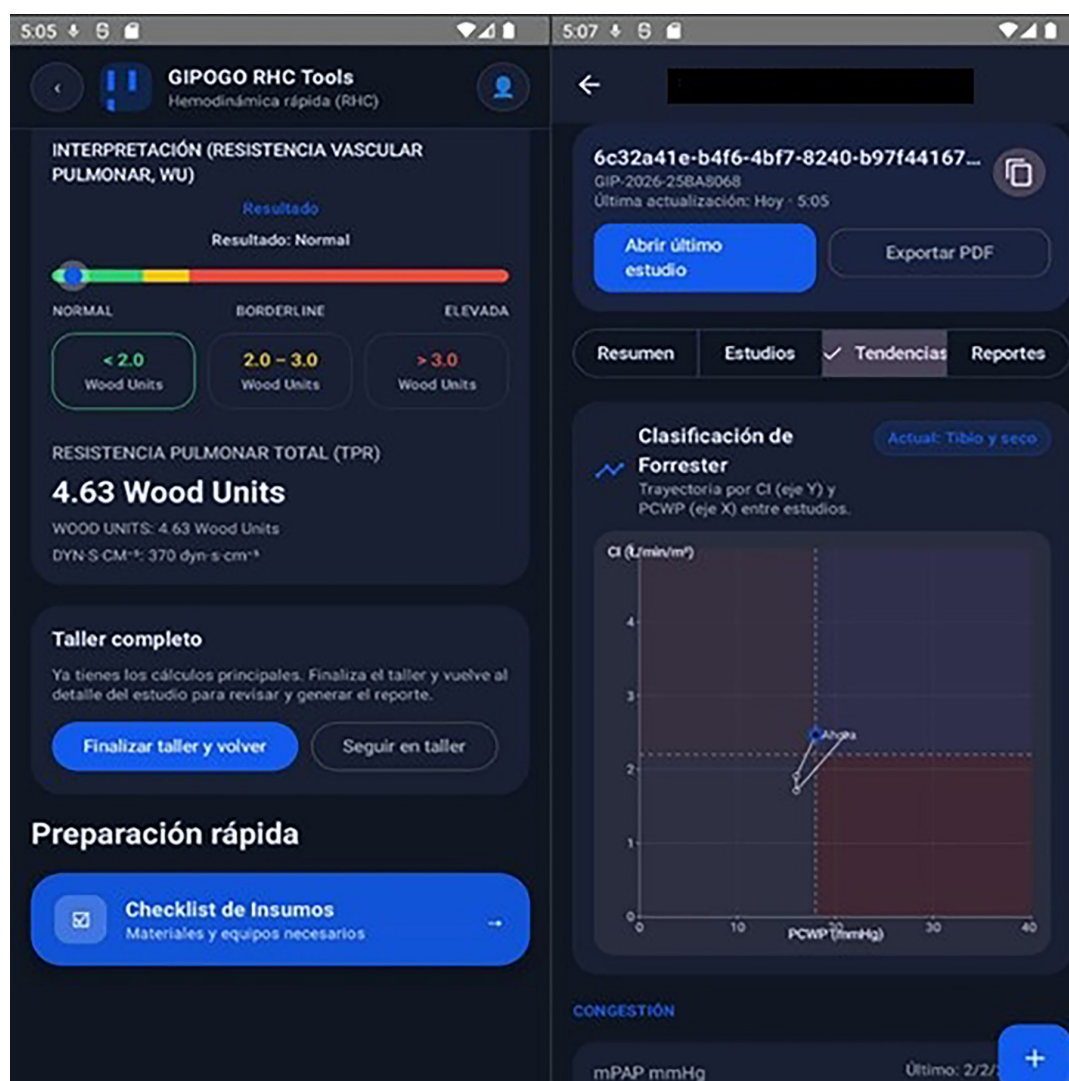


Figure 1: GIPOGO RHC Tools mobile application interface for invasive hemodynamic analysis. Left: module for automatic interpretation of pulmonary vascular resistance expressed in Wood Units, with range-based visual coding and conversion to $\text{dyn}\cdot\text{s}\cdot\text{cm}^5$. Right: longitudinal visualization of the patient with Forrester classification based on cardiac index and pulmonary capillary wedge pressure, allowing structured follow-up between studies.

an alternative to isolated calculators. The design incorporates data protection principles consistent with local clinical use. In accordance with the principles of data minimization and protection, the application uses device-managed authentication (preferably biometric) at the start of the session. Persistent data is stored in an encrypted local database on the user's device and does not require transmission to servers to function. These data are used to generate graphs and reports. Data temporarily stored in memory is used solely to maintain the workflow's operational continuity.

The handling of measurement units for variables is based on maintaining canonical units, with centralized conversion decoupled from the user interface, enabling flexible visualization without the risk of double conversion.⁴

The application groups flow variables (cardiac output and cardiac index), with options for the Fick or thermodilution methods and prior validation; resistance and power measurements; visualizations of the hemodynamic profile (e.g., Forrester classification); longitudinal trends when a series of studies is available; and input safeguards to prevent the storage of invalid or non-finite results as clinical data (*Figure 1*).

This tool operates locally on a mobile device and is intended for a single user. Therefore, it does not replace electronic health records or access controls at healthcare institutions. These limitations are explicitly stated in the application's legal notice/disclaimer, particularly on the «User responsibility» screen, which reminds clinicians to verify the accuracy of the data entered (including units) and to ensure its use complies with institutional policies and applicable regulations. These considerations are presented within the current scope and represent potential areas for expansion.

The discussion of this topic is justified for two main reasons. First, invasive hemodynamics

is particularly sensitive to errors in calculation, unit conversion, and traceability; relying on multiple independent online calculators can compromise reproducibility and preservation of clinical context. Second, standardizing hemodynamic recording at the session level and over time can promote comparability across measurements, support continuous improvement in the quality of care, and potentially generate research data.^{1,3,4} We invite discussion of minimum criteria for these tools (explicit and canonical units, input and output validation, traceability/auditability, and continuity of record).

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