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DIGITALIZATION OF EXAMS OBTAINED FROM AN EXISTING ELECTROCARDIOGRAM ANALOG EQUIPMENT IN A UNIVERSITY HOSPITAL (HUOL/ UFRN) AND THEIR INTEGRATION WITH THE HOSPITAL MANAGEMENT APPLICATION

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Abstract: According to the World Health Organization (WHO), cardiovascular diseases are the main causes of death in the world. Diagnosing these diseases quickly and accurately is of great importance in the treatment of patients. The analysis of the electrocardiogram (ECG) test, since its invention, has been one of the most used tools for carrying out this diagnosis. The exams are performed using electrocardiograph equipment. In some hospitals, this equipment still records these records in printed form for analysis by the clinical team, with no connection to the existing electronic medical record system. With the expansion of increasing computerization in health services, recording patient records in digital format is significant. The Onofre Lopes University Hospital (HUOL) uses a tool developed by EBSERH, called AGHU, adopted as a standard for all University Hospitals. This project proposes the digitalization of electrocardiogram exams at the HUOL cardiology outpatient clinic. Work was carried out with the aim of making the ECG accessible for storage, consultation and research by the institution's medical team, teachers, students and researchers. Software produced by the equipment manufacturer was used to digitize the exam directly into the computer, and with the IT team the AGHU module was implemented on the computers available in the cardiology outpatient clinic. It is concluded that the analog equipment, with the addition of software, performed the examination in digital format, facilitating diagnosis, improving patient care and giving access to all members of the institution at the same time.
Keywords: Electrocardiogram; Electrocardiogram scanning; ECG software.

INTRODUCTION

According to the World Health Organization (WHO), cardiovascular diseases are the main causes of death in the world. According to the Brazilian Society of Cardiology (SBC), from the beginning of 2024 until April 6, 2024, approximately 106,600 deaths from cardiovascular diseases (CVDs) were recorded in Brazil (SOCIEDADE BRASILEIRA DE CARDIOLOGIA, 2024). Still according to the entity, for comparison purposes, in Brazil deaths caused by CVDs represent more than double the deaths caused by all types of cancer combined, more than triple the number of respiratory diseases, 6.5 times more than all infections (including AIDS) and 2.3 times more than deaths due to external causes, such as traffic accidents and violence (BRAZILIAN SOCIETY OF CARDIOLOGY, 2020), (WORLD HEALTH ORGANIZATION, 2020)(Oliveira.G.M.M et al., 2023).

In this scenario full of challenges and expectations, the electrocardiogram stands out as a symbol of optimism. Its unique ability to transform the heart's electrical beats into detailed graphs offers an unparalleled perspective on a person's heart health.

In a constant quest to unlock the secrets of the human heart, Augustus Waller and Willem Einthoven emerge as renowned pioneers of modern cardiology. In an instant characterized by courage in the scientific field, Waller, in 1887, took the initiative to explore the mysteries of the heart muscle by creating the first electrocardiogram (ECG) using an improvised electrometer and electrodes placed on a volunteer's chest. A scene that is both challenging and epic, showing the first signs of electricity that precedes the synchronization of the heartbeat (Boriani & Vitolo, 2019) (Baldassarre, A et al., 2020).

However, it was with the genius of Einthoven, in 1902, that the real revolution took place. By connecting the wires to the patient's limbs, immersed in electrolytes in a container, and operating a huge machine weighing around 300 kilos, he made the electrocardiograph work, exploring new perspectives in understanding the human heart.

One of the most important tools for this diagnosis is the analysis of the electrocardiogram (ECG), an exam that provides a graphic representation, containing temporal and morphological data of the heart's electrical activity. It became popular because it is a non-invasive, relatively cheap, widely available, quick and easy to perform exam, remaining to this day as one of the main complementary exams in daily clinical practice, having high sensitivity for the diagnosis of various diseases, both in the environment outpatient settings such as urgency and emergency units (REIS et al., 2013) (PASTORE et al., 2019) (Magalhães, 2021).

The printed ECG brings with it a series of obstacles. Because it is printed on thermal paper, the quality of the print tends to decline over the years. Another point to be mentioned is that the way in which the documents are stored is very important, since this exam needs to be accessed periodically, in order to have the patient's health history. In some cases, printed exams are in the possession of only patients, who are responsible for storing and maintaining the documents, handing them over to the doctor when requested. As a result, many records can be lost or damaged. In cases where records are kept in health units, storage difficulties arise due to the physical space they occupy and the conditions in which they need to be maintained to avoid being damaged. Furthermore, the exchange of information between health units has become very important, which would be facilitated if the information were in a digital format (PATIL; KARANDIKAR, 2017) (TUN; MOE; NAING, 2017).

Therefore, the objective of this project is to add to the analog ECG device the function of sharing exams digitally, whether by PDF, DICOM or JPG, through software installed and integrated into the Management Application for University Hospitals (AGHU). This process aims to assist clinical research and quality improvement initiatives, reduce costs by eliminating the physical printout of the exam, allow the clinical team to view the exams in the patient's electronic medical record and protect the patient's entire evolution, clinical data and the history, in order to avoid loss or damage to the exams. Make clinical research and epidemiological studies faster and more effective, providing a database rich in cardiological information, favoring the obtaining of images for medical professionals, researchers, healthcare students and patients.

MATERIALS AND METHODS

To carry out this work, we used Bionet electrocardiograph equipment, model Cardiocare 2000 with 12 channels, Acer Notebook, TP-Link EC220-G5 Wireless Router, Management Application for University Hospitals, EKG Viewer Software, BMS Server Software, Patient Simulator - Handy Sim HS-30, with samples (previously carried out exams) taken from cardiology computers, without the need for contact with the patient.

The project began with a literature review on image processing and software models aimed at ECG digitization.

The installation and configuration of the EKG Viewer software and the BMS Server software, essential for adding the digitization function to the previously analog equipment,

was carried out. The EKG Viewer is the one that translates the electrical signals sent by our heart into graphic format, while the BMS Server is the one that makes the connection between the computer and the ECG device possible. From the direct connection between the notebook and the ECG device, network and IP configurations and modifications were necessary for the objective to be achieved, configurations that enabled the connection between the machines via crossover network cable to later evolve into a connection via the internal network.

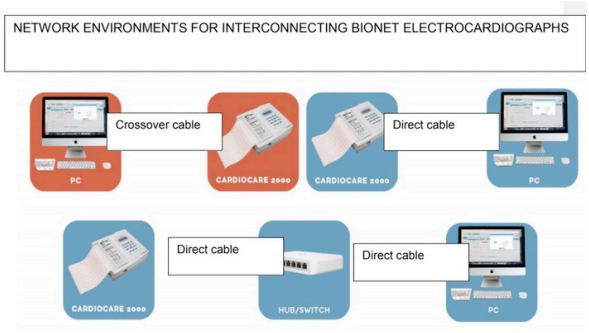

Figure 1. PC interconnect models - CARDIOCARE 2000

With the first stage completed, the next step was to isolate an ECG device together with a notebook, in order to carry out tests without the need to delay the exams carried out in the day-to-day routine at the outpatient clinic. In order to improve and guarantee safety, all tests carried out with the Software were performed using a heart rate simulator, directly between machine and machine, without the need for testing on humans and animals.

Figure 2: Notebook connected to Cardiocare 2000

Source: elaborated by the author (2024).

Figure 3: Heart rate simulator for testing.

Source: elaborated by the author (2024).

Therefore, together with the IT team, the AGHU module was implemented on the two computers available in the cardiology outpatient clinic, allowing the ECG machine operator to attach all the exams performed to the hospital's internal storage system.

After the first tests with positive and satisfactory results, small individual training sessions were carried out with the nursing team that operates the electrocardiogram devices on a daily basis, in order to teach

the entire step-by-step process of using the software and resolve any doubts that might arise. with the new image acquisition method.

Currently, the implementation of the electrocardiogram examination digitization method, together with the internal storage module via AGHU in the HUOL cardiology outpatient clinic, brings with it several benefits for the university hospital and its patients.

DISCUSSION AND RESULTS

The results of the project to digitize electrocardiogram exams at the HUOL cardiology outpatient clinic demonstrated significant advances in terms of operational efficiency, accessibility of medical records and quality of patient care. The implementation of digitalization of exams allowed efficient integration with the patient's electronic medical record, providing quick and easy access for the medical team, students, teachers and ensuring better organization of patient data. This integration is essential to ensure effective management of clinical information, enabling more accurate decision-making and bringing direct benefits to the patient.

According to the study by Li et al., (2022), the digitization of medical records is a growing trend in healthcare, due to its potential benefits in terms of operational efficiency and quality of care.

Careful. The results of our project corroborate the trend identified in Li's work, demonstrating that the integration of electrocardiogram exams into the patient's electronic medical record results in a significant reduction in the time needed to access and analyze the records, allowing a faster response to needs patient clinics.

When compared with the studies by (GONZALEZ; WOODS, 2008) and (Regis, Caldeira & Gurjão, 2016) (Marques da Silva et al., 2019) it was observed that advanced image processing techniques, such as different types of filtering, have been developed so that the accurate extraction and analysis of digital electrocardiogram signals has less chance of error. These technologies play a crucial role in the digitalization of exams, allowing accurate and reliable capture of cardiac signals, which is essential for accurate interpretation by healthcare professionals. The studies by González, Régis, Caldeirão and Gurjão are in line with the results obtained in our research, since the answers found during our work process are aligned with the work of the researchers mentioned above.

Furthermore, the digitization of exams resulted in a significant reduction in operational costs associated with physically printing records. According to the study by (Petmezas et al., 2022), eliminating the use of paper can lead to substantial savings in financial and material resources, contributing to more efficient management of resources in the healthcare sector. The results of our project coincide with the conclusions of the aforementioned researchers, demonstrating that the digitalization of electrocardiogram exams not only reduced operational costs, but also contributed to reducing the environmental impact associated with the consumption of natural resources and the generation of waste.

The research by Galdino et al (2013) and proposes a great social contribution, since their work has a social reach with the decrease in demand for care within hospital networks. Our research, in addition to promoting a lower demand for hospital care, also allows availability and ease of accessing digitized exams, making it faster and more effective to carry out clinical research and epidemiological studies, providing a database rich in cardiological information. The analog equipment converted to digital via software was able to help the professionals responsible to carry out exams more quickly, provide a better diagnosis and also facilitated access

to exams for students, teachers, healthcare professionals and patients.

The discussion of these results highlights the importance of digitizing medical records for the modernization of healthcare services, providing a solid basis for future research and developments in the area. The integration of electrocardiogram exams into the patient's electronic medical record represents a significant advance in clinical practice, providing a more efficient and sustainable approach to storing, consulting and researching medical information. These advances have the potential to significantly improve the quality of patient care, contributing to better clinical outcomes and more effective management of healthcare resources (Gomes, 2021).

FINAL CONSIDERATIONS

Based on the above, we can conclude that:

- The proposed objectives were fully achieved, contributing significantly to technological advancement in the cardiology outpatient clinic.
- Implementation of Digitization of Exams. Electrocardiogram exams are now digitized directly on medical equipment, eliminating the need for printing on paper.
- Integration with the Electronic Medical Record. Digitized exams are easily incorporated into the patient's electronic medical record in the AGHU system, providing quick and easy access for the medical team.
- Cost reduction and Environmental Impact. The elimination of physical printing of exams resulted in a significant reduction in operational costs and contributed to environmental sustainability initiatives.
- The ease and availability of access to ECG exams has made it faster and more effective to carry out clinical research and epidemiological studies, providing a database rich in cardiological information, favoring the obtaining of images for medical professionals, researchers, students in the field health and patients.
- The digitization of electrocardiogram exams and their integration into the patient's electronic medical record represented a substantial change in the way data is collected, stored and accessed by the medical team, in addition to providing the patient with a better post-exam experience.

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