v. 3, n. 41, 2023

Journal of Engineering Research

CONTRIBUTIONS OF CLINICAL ENGINEERING IN THE MAINTENANCE OF MECHANICAL VENTILATORS AND MULTIPARAMETRIC MONITORS IN THE COVID-19 PANDEMIC IN TERESINA–PI[1]

Pedro Felipe Araujo Alves de Sousa
Bachelor's Degree in Electrical Engineering, Centro Universitário Santo Agostinho, Electrical Technician, Instituto Federal do Piaui, Teresina – PI
UniFSA

Patrese Veras Quelemes
Bachelor's Degree in Electrical Engineering, Universidade Estadual do Piauí, Master in Electrical Engineering by: Universidade Federal de Campina Grande and professor at: Centro Universitário Santo Agostinho, Teresina – PI
UniFSA

Fábio de Araújo Leite
Bachelor's Degree in Electrical Engineering, Universidade Federal do Ceará, Master in Production Engineering by: ``Universidade Paulista``, coordinator and teacher of: Centro Universitário Santo Agostinho, Teresina – PI
UniFSA

1. Work presented at the 1st International Science and Society Congress (CICS 2023), ministered by: Centro Universitário Santo Agostinho, de 04 a 07 de outubro de 2023, em Teresina-PI;

Fatima Lidiane Viana Silva
Bachelor's Degree in Physiotherapy, Universidade Estadual do Piauí, Specialist in Neonatal and Pediatric Intensive Care at COFFITO, Teresina-PI
UESPI

Abstract: This article is a study on the contributions of Clinical Engineering to medical equipment maintenance services, during the Covid-19 pandemic in a hospital in Teresina/Piauí/Brazil, whose importance for the national scenario made the Hospital health network unit Poty River (HRP) a reference in the state. The research was quantitative in nature and a case study was carried out on electromedical equipment, analyzing mechanical ventilators and multiparametric or bedside monitors, observing maintenance, as well as research in the hospital (HRP). The main objective of this study is to present Clinical Engineering and to study its functionalities, identification of technical responsibility for maintenance, the choice of contribution methods and their role in the hospital area, analyzing the current scenario and characteristics of the equipment, the criticalities, and the main maintenance collected throughout the research. In this study we analyzed ICU equipment and emergency stations, different companies are needed to carry out maintenance, to facilitate the speed of the process, some measures were adopted to contribute even more to Clinical Engineering.
Keywords: Clinical Engineering. Electrical medical equipment. Hospital maintenance.

INTRODUCTION

Clinical Engineering (CE) is the branch corresponding to professionals who apply and develop scientific technical knowledge focused on health technology with the aim of providing better patient care. Electromedical equipment is systems embedded in microprocessors or microcontrollers with the purpose of assisting doctors in diagnosing, treating and monitoring their patients. As an example of equipment in times of the Covid-19 pandemic, it played a fundamental role as life support equipment, mechanical

ventilation equipment that replaces, totally or partially, spontaneous ventilation in patients with respiratory failure resulting from various pathologies, whether acute or chronic, which have become well known today in the treatment of patients with Covid-19. Clinical Engineering's daily objective is maintenance and calibration, to ensure that healthcare professionals have quality equipment available within the hospital medical scope and within the desired standard (SOUZA; MILAGRES; SOARES, 2012).

It is an extremely important sector within hospitals and clinics. It began in the 1960s when engineers were encouraged to enter hospital sectors to maintain the technological apparatus. In Brazil, this occurred during the 90s, a group made up of six engineers were trained to work in the first advanced EC workshop. The role of the clinical engineer has changed over the years. Previously an employee responsible only for repairing equipment, currently part of the interdisciplinary team (TERRA et al., 2014).

The technological advances used in the medical intervention and diagnostic area over recent years require better investment in physical resources capable of better serving those seeking hospital medical services. Kardec and Nascif (2015) discuss five types of maintenance: preventive, predictive, corrective, planned corrective and detective maintenance, which make up maintenance engineering, as the National Health Surveillance Agency (ANVISA) and the International Electrotechnical Commission (IEC)60601 regularize metrological calibration services and electrical safety of equipment and their approach in medical services.

The safety of patients, professionals and everyone involved in healthcare has always been a priority in a hospital institution. Biosafety procedures within the scope of EC aim to preserve life, control, eliminate and prevent possible risks linked to adverse effects of new technologies on patient safety, which may affect the environment, human health and all involved in care, whether the patient or the multidisciplinary team (PORTO; MARQUES, 2016).

Hospital logistics' main challenge is to meet organizational needs correctly and efficiently, helping to reduce and optimize material resources that directly impact cost reduction, without forgetting to prioritize people's health. One of the support sectors stands out as Clinical Engineering, which is responsible for the acquisition, evaluation, maintenance and deactivation of the hospital's technology park. The proper functioning and quality of this equipment can interfere with patient care. Therefore, it is essential that they are up to date with maintenance (SOUZA, 2013).

Quality in healthcare involves the direct relationship between healthcare users and service providers, as there is an adaptation between the service provided and the expectations of those who receive it. Not only quality is important, but also the evaluation of services and the standards offered to patients. An independent plan organized to evaluate and authenticate hospitals and healthcare institutions. Accreditation evaluates the quality of services from the point of view of those who apply its methodologies (TERRA; BERSSANETI, 2017).

It is of fundamental relevance in the health area, the use of technological tools for diagnosis and treatment of patients and with the increasing increase in the use of electronic equipment in hospitals, as well as its proper functioning, management, maintenance and preventive measures, it is necessary to From this point of view, the professional responsible for the execution, maintenance and correction of this equipment is the clinical engineer. As explained: What are the

technological contributions and the role of Clinical Engineering within a hospital?

Therefore, the objective of this work is to present the reinforcement of the maintenance of electrical medical equipment for the sectors of Hospital Rio Poty (HRP), based on EC, aiming to provide an improvement in the provision of health services to patients and safety for employees who handle such equipment. It must be noted that the preparation of this plan was contemporary with the scenario of the pandemic caused by Covid-19, and took into consideration, the recurring changes to the protocols inherent to the pandemic in the hospital in question.

METHODOLOGY

To prepare this article, a review of the technical literature on CE was carried out with a focus on medical equipment. The main directories adopted were the Brazilian Association of Technical Standards (ABNT), the Institute of Electrical and Electronic Engineers (IEEE), The Scientific Electronic Library Online (Scielo). It is observed that some of the main bibliographical references considered in the preparation of this article were the books of the authors: Kardec and Nascif (2015), Pereira (2019), they address the types of maintenance currently used, indicating their advantages and disadvantages in each process, ANVISA and IEC 60601 regulate electrical safety services and metrological calibration of equipment and their approach to medical services.

The development of this study had a quantitative nature, data analysis constitutes a work that encompasses a set of procedures, techniques designed to help the researcher extract subsidies from these data to answer the questions that he established as the objective of his research. (GATTI, 2004).

The predominant type of research was descriptive, where documentary and bibliographic data were collected that the HRP maintenance sector has for analysis. This area has a folder saved on the cloud-based Intranet, which contains all the documents with the companies that provide the service. in the maintenance area for the hospital, equipment output, maintenance and records.

From field research at HRP, the equipment that makes up the technology park was identified, and the most important sectors and devices to be considered and proposed in this work were selected. During the field research, periodic visits were made to the hospital to identify and collect data to prepare a spreadsheet quantifying the machinery, function, maintenance, calibrations and corrections carried out, as well as the number of existing active machines.

The collection carried out at the hospital included access to its database, as well as conversations with professionals responsible for the maintenance sector, clinical engineering sector, technicians and administrative assistants.

RESULTS AND DISCUSSION

The term maintenance can be conceptualized as the operation/realization of conserving, sustaining, repairing something or something. In this study, five types of maintenance applied to EC will be worked on, these are: preventive and corrective maintenance, which are considered an integral part of maintenance engineering. ANVISA and IEC60601 regulate electrical safety services and metrological calibration of equipment and their approaches to medical services. Among the types of maintenance, the most used are preventive maintenance and corrective maintenance, which will be explained in the following paragraphs.

Preventive maintenance – MP emerged with the aim of reducing the downtime of assets, ensuring confidence in the

production process. According to ABNT-NBR-5462 (1994), preventive maintenance is "maintenance carried out at predetermined intervals, or in accordance with prescribed criteria, designed to reduce the probability of failure or degradation of the functioning of an item". For Kardec and Nascif (2015), preventive maintenance "is the action carried out based on previously prepared plans based on defined intervals (time, mileage, quantity processed, etc.)".

As this type of maintenance is carried out at a pre-determined time, maintenance ends up being carried out without the real need for it or ahead of time, thus causing possible unnecessary expenses or expenses that could be avoided for longer if the asset was being monitored. in some way to identify faults.

Among the types of maintenance, the most used is corrective maintenance – MC, which consists of "maintenance carried out after the occurrence of a breakdown aimed at restoring an item in a condition to perform a required function". However, most of the time it is not the most appropriate, because for its execution the asset, which needs repair, remains idle, making its production or availability impossible.

In his book, Pereira (2019) lists some situations in which MC is of great importance, such as in assets with low operating costs, assets with backup, with faster operation, that do not directly affect production, that are easy to maintain and the which have well-trained technicians for prompt repairs.

REGULATORY SERVICES

Regulatory services are mechanisms that work with regulatory problems, analyzing prior to the publication of normative acts of general interest, which will contain information and data on their possible effects, to verify the tolerability of the impact and support decision-making. In Brazil, the bodies that regulate these issues are ANVISA (National Health Surveillance Agency) and IEC 60601 (General requirements for basic safety and essential performance - Collateral standard: usability). Among those that will be worked on in detail are: calibration, electrical safety.

Calibration is a process related to metrology. It is carried out to ensure that the equipment is working properly and delivering the results it is supposed to deliver. To do this, the manufacturers' technical standards are checked, in addition to the specific standards for each piece of equipment. Uncalibrated equipment that continues to work can pose risks to patients and professionals who use it, compromising the diagnosis and even the health of both (MINISTRY OF HEALTH, 2019).

Electrical safety is a series of technical standards that guarantee the safety of medical equipment. IEC 60601-1 addresses the basic safety and essential performance requirements of medical equipment and serves to ensure that no individual electrical, mechanical or functional failure represents an unacceptable risk to patients and/or operators.

ELECTROMEDICAL EQUIPMENT

The definition of medical equipment by (ANVISA) is all equipment used in healthcare for medical, dental, laboratory or physiotherapeutic purposes, used directly or indirectly for diagnosis, therapy, rehabilitation or monitoring of human beings and, also, those for of beautification and aesthetics (ANVISA, 2020).

During the Covid-19 pandemic, the hospital used a series of equipment to better diagnose patients with or suspected of this disease. In the ICUs and emergency stations, some of the equipment listed below were used: continuous infusion pumps, defibrillators/ cardioverters, multiparametric or bedside monitors and mechanical ventilators.

INTENSIVE CARE UNIT (ICU) EQUIPMENT

In hospitals there is an area for highly complex patients, it is called ICU (Intensive Care Unit). The electrical medical equipment is intended for 24-hour care for patients in serious condition who require more complex care. The focus of this article's analysis is mechanical ventilators, which are essential for the proper functioning of an ICU, as they ensure the necessary ventilation for the patient.

MECHANICAL FANS

Ventilators are considered equipment, or life support system, "intended for use in critical care environments in hospitals or for use in transportation in a hospital unit." Responsible for "replacing" the function of the patient's lungs, assisting in ventilation and gas exchange, with parameters programmed for each type of patient, maintaining oxygenation until they recover and return to their ideal state of activity. Ventilators run on electrical or pneumatic energy, which are responsible for powering the set of valves used to regulate the flow of gas that goes to the patient (ANVISA, 2011).

Figure 4: Mechanical fan

Source: Maquet Gettinge, 2019.

MULTIPARAMETRIC MONITOR OR BEDEDGE

Bedside monitors allow continuous patient monitoring, providing alerts of risk situations. Physiological data are displayed continuously, allowing quick interpretation of information and faster intervention by the healthcare team, if necessary. The current generation of monitoring devices are capable of interconnection via an Ethernet network and IP protocol and can transmit their data to a monitoring center.

The center brings together data from different devices, allowing centralized monitoring of different patients. Monitors and centers can also be integrated with third-party systems through standardized messages, mainly using Health Level 7 (HL7), which is an international standard for representing and exchanging clinical and administrative data between information and health systems (MORENO; GUTIERREZ, 2016).

Figure 3: Monitoring Center

Source: Dräger, 2021

FINAL CONSIDERATIONS

Therefore, it is not enough to just carry out maintenance, Clinical Engineering has to know how to work with management, because it involves the entire medical team. During the Covid-19 pandemic, the workload was completely hectic and exhausting, in addition to having contact with the patient themselves. But knowing how to work with people management and the organization of equipment maintenance, so that it works without the hospital stopping and without having to cancel an appointment or surgery,

is extremely important for carrying out the clinical engineer's service.

At the current time, health institutions have increasingly invested in medical and hospital equipment due to applicability and technology, Describe the importance of Clinical Engineering in health institutions, emphasizing the experience in the Hospital, which EC contributes to the management of hospitals in the modernization of sectors, ensuring efficiency in patient care with a relatively considerable saving of financial resources, and its implementation has an effective participation both in engineering projects (renovations and expansion) and in equipment management, contributing to the quality in assistance services.

The hospital hires engineering with the role of solving problems and mitigating or avoiding costs for the location, having to find the best output and development for the health unit, in addition to defining actions and procedures aimed at safety, usability and proper functioning of the equipment that makes up this infrastructure.

In this sense, to bring and offer the best technology to the hospital, demonstrating a future investment in equipment, which would be interesting for the best quality of medical exams, to always meet and solve problems, always maintaining the focus on the safety of nurses, doctors and patients.

Based on what was developed in this study, future work may cover several areas of Clinical Engineering within the hospital context, highlighting other topics that are increasingly relevant to the area of medical technology, pointing mainly to the technical and scientific development of this field, with extremely important for patient safety and for new generations with the advancement of Engineering.

REFERENCES

ALMEIDA FRANÇA,Alex Sandro de.**A Atribuição Profissional n aGestão de Tecnologias em Estabelecimentos de Saúde no Brasil**.Revista Organização Sistêmica, v. 7, n. 4, 2015.

ALMEIDA, Lucas ;**Regularização de equipamentos hospitalares: o que diz a Anvisa : Nexxto,** Nexxto, São Paulo, dez 2021. Acesso em: 04 de junho de 2023;

ANVISA. AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA.**Abordagem de Vigilância Sanitária de Produtos para Saúde Comercializados no Brasil**: Ventilador Pulmonar. Brasília, DF: ANVISA, 2011.Acesso em: 27 de maio de 2023.

ANVISA. AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA. **Instrução normativa – In N° 47, dispõe sobre as Boas Práticas de Fabricação complementares às atividades de qualificação e validação**. Brasília, DF: ANVISA, 2019.Acesso em: 04 de junho de 2023.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **ABNT NBR 5462**: **Confiabilidade e mantenabilidade**. Rio de Janeiro: ABNT, 1994.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **ABNT NBR ISO 80601-2-12**: Requisitos particulares para a segurança básica e o desempenho essencial de ventiladores para cuidados críticos. Rio de Janeiro: ABNT, 2014.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **ABNT NBR IEC 60601-1-2**: Requisitos gerais para segurança e desempenho essencial- Norma colateral: perturbações eletromagnéticas – requisitos e ensaios. Rio de Janeiro: ABNT, 2017.

BERNADETE A. GATTI. **Educação e pesquis**a, são paulo, v.30, n.1, p. 11-30, jan./abr. 2004.

BRASIL. Ministério da Saúde. Secretaria de Gestão de Investimentos em Saúde. Projeto REFORSUS **Equipamentos Médico-Hospitalares e o Gerenciamento da Manutenção**: capacitação a distância / Ministério da Saúde, Secretaria de Gestão de Investimentos em Saúde, Projeto REFORSUS. Brasília, DF: Ministério da Saúde, 2002. Disponível em:http://bvsms.saude.gov.br/bvs/publicacoes/equipamentos_gerenciamento1.pdf. Acesso em: 27 de maio de 2023.

BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. **Resolução nº 2, de 25 de janeiro de 2010.** Dispõe sobre o gerenciamento de tecnologias em saúde em estabelecimentos de saúde. Brasília, DF: Ministério da Saúde, 2010. Disponível em:http://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2010/res0002_25_01_2010.html Acesso em: 27 de maio de 2023.

CALDAS FILHO,J.S; CALDAS,A.J.M;COSTA NETO,M.L: **A importância da engenharia clínica nas instituições de saúde: experiência em um hospital público federal.** Rev.Pesq.Saude,maio 2015.

CENTRAL DE MONITORIZAÇÃO, **Central de Monitorização Vista 120.** Disponivel em: Sistemas de monitorização de pacientes — para otimização de fluxo de trabalho no hospital todo (draeger.com),2019. Acesso em :28 de maio de 2023.

CONSTITUIÇÃO FEDERAL**. (ARTIGOS 196 A 200) SEÇÃO II DA SAÚDE**. Disponível em: https://conselho.saude.gov.br/web_sus20anos/20anossus/legislacao/constituica ofederal.pdf.Acesso em 27 de maio de 2023.

DELSOLAR,JoãoGabrielMartin.**A formalização das atividades de engenharia clínica e hospitalar, próprias e terceirizadas**. [S.l.: s.n.], 2017. Acessado em: 25 de maio de 2023.

PORTO, D; MARQUES, D.P: Engenharia clínica: nova "ponte" para a bioética? Rev.Bioet. Set- dez 2016.

RESOLUÇÃO RDC Nº 63, De 25 de Novembro de 2011: disponivel em **:** https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2011/rdc0063_25_11_2011.html. Acesso em 25 de maio de2023.

SOUZA, Alexandre Ferreli. **Engenharia Clínica: Como Fiscalizar?**[S.l. s.n.], nov. 2016.

SOUZA, A.A; PEREIRA, A.C; XAVIER, A.G; XAVIER, D.D; MENDES, E.S: **Logística hospitalar: Um estudo de caso diagnóstico das dificuldades na logística do setor de engenharia clínica.** Rev Eletrônica de Administração, v 12 n 1 ed 22 jan-jun 2013

SOUZA, D.B; MILAGRES, S.T; SOARES, A.B: Avaliação econômica da implantação de um serviço de Engenharia Clínica em hospital público brasileiro. Rev. Bras.Eng. Biomédica, dez 2012.

TERRA, J.D.R; BERSSANETI, F.T: **Acreditação hospitalar e seus impactos nas boas práticas em serviços de saúde.** O mundo da saúde, São Paulo, 2017; 4.

TERRA, T.G; GUARTENTI, A; SIMÃO, E.M; RODRIGUES JÚNIOR, L.F: **Uma revisão dos avanços da engenharia clínica no Brasil.** Disciplinarium Scientia v 15. n1 p 47-61, 2014.

TEIXEIRA, Verônica Cilâine; MASSONI, Neusa Teresinha; VARGAS, Ghisiane Spinelli: **Raios X: Um Tema Instigante Para A Introdução Da Física Moderna E Contemporânea Na Sala De Aula Do Ensino Básico.** Experiências em Ensino de Ciências V.12, No.2, 2017.

VENTILADOR MECÂNICO, **GETINGE MAQUET, SERVO-I**. Disponível em: Soluções, 2019. Acesso em: 28 de maio de 2023.