Special Session Title:

COVID-19 in Latin America, efforts, success, and lessons to learn - Part 1

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Theme:

- ○ 01. Biomedical Signal Processing
- ○ 02. Biomedical Imaging and Image Processing
- ○ 03. Micro/Nano-bioengineering; Cellular/Tissue Engineering &
- ○ 04. Computational Systems & Synthetic Biology; Multiscale modeling
- ○ 05. Cardiovascular and Respiratory Systems Engineering
- ○ 06. Neural and Rehabilitation Engineering
- ○ 07. Biomedical Sensors and Wearable Systems
- ○ 08. Biorobotics and Biomechanics
- ○ 09. Therapeutic & Diagnostic Systems and Technologies
- ○ 10. Biomedical & Health Informatics
- ◉ 11. Biomedical Engineering Education and Society
- ○ 12. Translational Engineering for Healthcare Innovation and Commercialization

Special Session Synopsis— Max 2000 Characters

During the global health emergency caused by the SARS-COV 2 virus, also known as COVID-19, several working groups globally made joint proposals to solve urgent problems considered priority to be attended. There were some success cases, in which ideas, designs and technological developments had a direct impact on improving patient care and protection for healthcare professionals. In the last year there have been efforts all around the world in the development of medical technology, generation of reconversion protocols for hospitals and public areas, research to have a better understanding, diagnosis and monitoring of patients with COVID-19, the creation of a vaccine, among others; where health care professionals (clinicians, researchers from different areas, biomedical engineers, among others) have been working at an incredible pace to contain the pandemic as much as possible.

However, COVID-19 has highlighted the deficiencies or weak points in health systems around the world, but also it highlighted the relevant role of science and technology in the development of solutions to face COVID-19. Some opportunity areas related to the process of generation and validation of medical devices were also evident, as well as different reasons that did not allow for expeditious collaborations between scientists, industry and regulatory agencies. In addition, in many Latin American countries, the lack of resources and infrastructure deficiencies leave health care specialists in unfavorable situations facing COVID-19, forcing them to adapt according to their own particular situation in order to face the pandemic.

This special session aims to provide a place where different healthcare specialists in Latin America may present their reality

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Home-Based Monitoring of Covid-19 Patients using WBAN

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Abstract— **Monitoring of patients with respiratory conditions is routinely carried out in hospital centers. Our research proposes the implementation of a home tele-monitoring system based on the use of a Wireless Body Area Network (WBAN) for COVID-19 patients (WBAN-COVID19). Consequently, through the WBAN-COVID-19 system, the vital signs and location of the patients can be monitored, in a centralized, controlled, and orderly way, being able to analyze the evolution of the disease.**

Clinical Relevance—**Remote monitoring of physiological data outside a hospital environment would reduce potential risks of exposure to COVID-19 and to obtain relevant clinical information from patients.**

I. Introduction

Due to the rapid propagation capacity demonstrated by the coronavirus disease (COVID-19), healthcare systems have collapsed in a short period of time. The spread of infections, limited number of health care professionals and medical equipments for monitoring clinical information have made it challenging to provide adequate care to COVID-19 patients. The use of non-invasive devices facilitate physiological data acquisitions at the user level, simplifying the work of medical personnel [1]. Despite the potential of medical devices, there is a lack in the optimization and allocation of their resources.

Recently, the use of Wireless Body Area Networks (WBAN) are being investigated to provide and improve quality of service (QoS) tailored to clinical needs. A medical WBAN consists of medical devices to support the treatment, diagnosis, and monitoring of the patient's health [2], [3]. The main objective of this research is to propose a QoS monitoring systems for a large number of WBAN to monitor the evolution of COVID-19 patients at home (WBAN-COVID-19).

II. Methods

A WBAN topology in star configuration was proposed to collect data from biomedical sensors and transmitted to a mobile phone (network coordinator). For monitoring patients' health status in home isolation, the DMAIC (define, measure, analyze, improve, and control) tool was used for continuous improvement of the QoS metrics. The monitored QoS metrics are detection efficiency, data storage efficiency, normalized throughput, average end-to-end delay, energy efficiency, and packet loss. Pareto´s diagram analysis was used to organize the data obtained through the quantification of the QoS metrics according to their frequency of compliance or opportunity for improvement in the system.

III. Results

Figure 1 shows the Pareto Diagram for our study. The analysis of the non-compliance reveals energy efficiency metrics as the main metric to improve in the system (i.e., 13.1% of non-compliance).

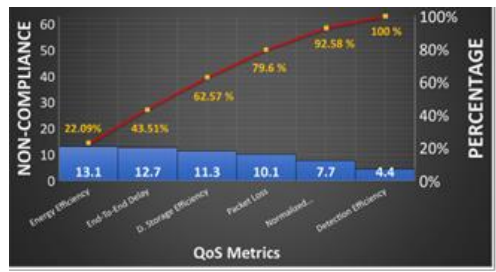

Figure 1. Pareto´s diagram of QoS metrics

IV. Discussion & Conclusion

WBANs can be a useful tool for home monitoring of COVID-19 patients. The application of WBAN-COVID-19 is very promising, being a key point the control of the QoS metrics to guarantee the correct communication of the medical data.

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Alternative Production of Strategic Inputs in Bahia-Brazil

Corniali, Alfredo[1], ABEClin; Souza, M. C. D., SECTI

Abstract — **This paper presents an experience report related to strategies used by the state of Bahia-Brazil to face the covid-19 pandemic. To respond to this challenge, it was organized a task force with the participation of many organizations, institutions, companies, and volunteers to find solutions for the absence of medical devices in the beginning of the pandemic. Many alternative solutions and productions were developed to provide, among others, face shields, non-invasive-ventilation accessories, ventilators maintenance, but the regulatory requirements were an obstacle.**

I. Introduction

The pressure on health systems and on the health market during the COVID-19 pandemic caused a collapse in the provision of supplies, materials, medicines, and a lack of lung ventilators. To reduce this impact, it was necessary to develop alternative solutions adding additional devices to those already existent on the market, accessible locally.

The objective of the project carried out in the State of Bahia-Brazil during the first months of the pandemic was to support, in an institutional way, the interaction between professionals, institutions, companies, volunteers, health services, civil society, nongovernmental organizations, and the government through the secretaries of Health, Planning, Science, Technology and Innovation (responsible for the project), for the development of non-traditional solutions, industrial reconversion and alternative production strategies. Promoting collaborative actions between them.

II. Methods

This work presents the experience report related to the alternative production of strategic supplies project carried on the earlier moments of the COVID-19 pandemic. The activities were divided in 7 stages: i.) identification of scarce products by the state secretary of health; ii.) prospecting collaborators: research and development centers, universities, industries, services sector, and volunteers; iii.) mapping of potential solutions; iv.) identification of regulatory requirements and necessary production methods, materials, tools, and equipment; v.) feasibility analysis; vi.) adaptation of production lines; vii.) production; and vii.) distribution.

III. Results

Technical groups were structured to support the production, in a collaborative way, acting as technical consultants, orienting production to the identified demands. Interaction and institutional network support were stimulated, which allowed the structuring of various projects. Some projects were independent of this initiative, they are included here to show the result of the collective efforts in what the author and other volunteers took part to face the pandemic.

Not all succeed, but these are some examples of the technical groups structured [1]: i.) Personal Protective Equipment, such as, masks, respirators, face shield and clothing ii.) Accessories for Non-Invasive Ventilation (NIV), 3D printed diving mask adapters such as Motirõ-Cidinha, Isinnova and Owntec, valves for ventilators, splitter connectors for the use of a single ventilator by multiple patients; iii.) High Efficiency Particulate Arrestance (HEPA) filters; iv.) Collective Protection Equipment, such as, intubation cabin, Manaus Transire-Vanessa, Motirõ and CIMATEC type patient isolation tent; v.) filtration and decontamination units with UV light, Ozone and chemicals; vi.) and Medical equipment such as prototypes of open source ventilator Breath4life printed in 3D, automated ventilator of Ambú Providence, development of manual for NIV with safe circuit for low cost CPAP with HEPA filter without equipment, development of prototype of helmet for NIV, software and applications for health services. It was also possible to structure a project for the donation, repair and distribution of CPAP equipment, and the Clinical Engineering Centers for the repair of medical equipment (Associação Brasileira de Engenharia Clínica – ABEClin, SENAI, Ministério de Economía / Br).

IV. Discussion & Conclusion

The social mobilization provided technical capacity, materials, and financial resources without major difficulties. Large companies and institutions contributed with actions in the donation of equipment, logistics and financial support, but due to bureaucratic requirements and compliance, the impact of the actions was limited. The results of collaborative actions exceeded initial expectations, even giving rise to industrial reconversion and new permanent projects.

As difficulties, we can point out that the regulatory requirements, and the existent producers constituted an important barrier for development, even discouraging the entry of new actors into the ecosystem of health products.

Lessons learned: Need to create permanent mechanisms to stimulate collaborative networks for the development of technological solutions for the health sector; incentives for the local productive sector; create diversification in health products and supply chain; support entrepreneurship; consolidate professional training in biomedical engineering and offer institutional support to comply with regulatory rules.

Acknowledgment

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Design of a Rapid Response Mechanical Ventilator during the COVID-19 pandemic in Panama

Alejandro Von Chong, Antony García, Julio Grossman, José Trujillo, Fernando Alfaro, Alicia Torres, Elida de Obaldía, Ernesto Ibarra-Ramírez and Rolando Gittens

Abstract— **The present article briefly describes the design of an emergency mechanical ventilator designed to respond to the global shortage during the COVID-19 pandemic in Panama. The proposed mechanical ventilator was meant to be scalable and quickly deployable to supply the country in response to the rapid surge in cases and a subsequent shortage in these devices.**

I. INTRODUCTION

The surge in demand of Mechanical Ventilators (MV) has been a critical issue worldwide during the COVID-19 pandemic. Panama has been one of the most severely impacted countries in Central America [1]. Issues such as export limitations from manufacturing countries to cover their local demand, asymmetries in the power of negotiation and price volatility due to speculation have all heavily affected smaller, developing countries used to importing biomedical technology [2-3]. This forced countries, such as Panama, to rely on their local scientific communities to produce MV with the resources readily available to them.

II. METHODS

The MV presented in this article is based on the continuous flow principle. For volume and pressure control, the design uses two proportional oxygen-compatible valves type 2873 (Burkert) for inhalation and intentional leak and an on-off valve type 6027 (Burkert) for expiration. Airway pressure measurement and flow estimation are done with two MPX5010 sensors (NXP). The device was tested with artificial lungs, medical simulation manikins and, finally, in a preclinical porcine model to validate its performance.

III. RESULTS

Figure 1 shows the final design of the MV model UTP-100P. When compared with the control ventilator using a gas flow analyzer (IMT Analytics), results show that the device is suitable for human mechanical ventilation required in case of emergency for COVID-19 treatment.

IV. DISCUSSION & CONCLUSION

The initial intention was to develop a MV with readily available or locally accessible components to cope with the surge in demand. However, we had to import certain

Figure 1. Continuous flow MV model UTP-100P

specialized components that are not locally manufactured; required to meet biomedical device standards, such as oxygen-compatible parts (in direct contact with the air flow) due to the hazards related to oxygen enriched environments.

The development of this MV was achieved in less than 7 months thanks to an active collaboration between engineers, intensive care physicians, academics and veterinarians, from both: the public and private sector; coordinated through the "Ventilators for Panama" initiative. This is an unprecedented feat for Panama, with no established medical device manufacturing industry. The goal of saving lives in case of a public health system collapse promoted a strong interinstitutional, interdisciplinary collaboration, even with very limited funding. COVID-19 also highlighted the need for health authorities to establish emergency-use regulatory pathways. Unexpectedly, despite the support from the Ministry of the Presidency and the National Secretariat for Science, Technology and Innovation (SENACYT), the acceptance of our device by the local health authorities turned out to be challenging, even if some neighboring countries did manage to accomplish the final regulatory objective. Culturally in Panama, there is an underestimation of the local technical capacities, as most medical devices are imported.

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Towards Survival Prediction of COVID-19 Patients using Computed Tomography (CT) and Deep Learning

A. Santos Díaz, L. Cendejas Zaragoza, J. Gutiérrez Mejía, M. Chapa Ibangüergoitia, J.G. Domínguez Cherit

Abstract—**As a response to the COVID-19 pandemic declared by the world health organization in March of 2020, many institution began their efforts to better diagnose, treat and overall, understand the disease. In Mexico, the ministry of health deployed their response plan that included designating healthcare institutions as COVID-19 attention only. Among them, the National Institute of Medical Sciences and Nutrition Salvador Zubirán (INCMNSZ) became a reference for critical care of such type of patients. Thus, it was due to the strong collaboration between Tecnológico de Monterrey and INCMNSZ that we began this project, taking advantage of their critical care expertise and ours on the development of image processing and artificial intelligence algorithms. The goal, to create an intelligent system capable of predicting the probability of survival in critical patients of covid-19, using CT images, clinical features and deep learning models. Our general idea is to extract relevant features from the chest CT images and merge them with other clinical relevant information in order to predict the outcome of a patient as early as possible in the progression of the disease. In this talk I will present the main challenges, current progress and future perspectives of this effort.**

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Clinical Engineering in Times of COVID-19: Experiences in Argentina of how a Virtuous Network was formedE

E. Fernández Sardá, E. Díaz, F. Paschetta, N. Lerendegui, M. Lencina, R. Acevedo.

Abstract— **The surprise arrival of COVID-19 in Latin America took us out of the state of normality in every aspect of the Healthcare System and we, the clinical engineers, were among the first to go on alert trying to correct the shortages of supplies and devices in order to face the overwhelming demand of assistance and medical services.**

This work present how a support network for clinical engineers was organized among colleagues from all over Argentina, and colleagues from neighboring countries were invited, in a short period of time with the aim to provide and share relevant information about how to manage the available resources and establishing priorities in such a way that resources were not lacking even in critical distant healthcare institutions.

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Internet of Medical Things (IoMT) applied to COVID-19

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Abstract— **The Internet of things (IoT), is a recent paradigm that attempts to solve day to day problems from a connectivity perspective. Technically, it describes a (wired or wireless) network of sensors and drives that are embedded into things. These type of electronic devices are often called embedded systems, and they interchange information amongst them and can also connect to the internet.**

The Internet of medical things (IoMT) is one aspect of IoT. This technological model incorporates wired and wireless sensors with internet access into medical equipment, enabling constant monitoring of human body activities. It can contribute to early diagnosis of some types of disease, symptom's control, as well as the building of the clinical history of the patient [1]. There are plenty of IoMT commercial applications available and the race to create more continues. One of the most popular is the Fitbit fitness wrist band. It measures heart rate, pulse, sleep hours, water intake, calories burned, steps and even the female reproductive cycle.

The COVID-19 pandemic awoke in all of us a sense of urgency and major interest in the monitoring of health in general and some physiological variables in particular. With this in mind, our group developed a project that aimed to help with the remote health monitoring of patients potentially infected by the virus, using IoMT.

The proposed system is called Rinku and it is based on a clinical kit that includes a pulse oximeter (JUMPER®), an infrared thermometer, a Bluetooth Gateway and a power source. When turned on, the oximeter connects to the gateway and the latter activates the infrared thermometer to capture the patient's temperature reading. The data is presented to the medical expert in a dashboard, through a web platform so he/she can follow up properly with the patient.

The use of IoMT may contribute significatively to performing a timely and accurate monitoring of health variables in patients, it improves accessibility to the information and, as a consequence facilitates the building of medical files. Both aspects represent very important steps towards the democratization of health and the improvement of medical services.

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