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HISTORY ARTICLE

The Central Laboratory of the *Hospital General de México*. Advances in diagnostic technology

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Introduction

Medicine, as a product of science, is based on the knowledge that has been generated through observation, experimentation, and deduction. However, science, in addition to generating knowledge, has also been able to generate technology and this, in turn, has served to generate knowledge and grow at the same time, feeding each other. Anton Van Leeuwenhoek, with a microscope, which he himself invented and elaborated, described blood cells in 1674 while current optics and histology allow us to see and differentiate the elements that make up it, for example. This inseparable duo (knowledge and technology) has contributed, historically, to the generation and improvement of equipment that allows the analysis and quantification of morphological and functional elements of almost any organ of a human being, which provides information on an individual, which is why it has become one of the fundamental tools that the doctor uses to diagnose, evaluate a treatment or predict the course of the disease; laboratory studies. Tertiary level hospitals, such as our *Hospital General de México* (HGM) *Dr. Eduardo Liceaga*, are highly complex institutions designed and equipped to attend to and solve the health problems of our country.[1] In this sense, we have trained personnel, as well as advanced and specialized technology that allows us to diagnose diseases and provide treatments. However, we do not only treat patients from our hospital, but we also provide care to patients referred from other institutions who do not have the necessary human and technological resources for their diagnosis and treatment. In such a way, the robotization of the Central Laboratory that began in 2007 has been of vital importance for medical care. In addition, its constant technological renewal has maintained the balance between care, science and teaching thanks to the digitalization processes that we now have and, by virtue of its avant-garde healthcare spirit, we will implement as a result of the technology in turn.

Who are we?

The Central Laboratory of the HGM is a service that is located in unit 205 of this hospital and provides care to patients who require our service 24 h a day, 365 days a year, providing quality, warmth and performing clinical laboratory analyses in an efficient and

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timely manner, to contribute to the diagnosis in the medical care of patients who attend the HGM. We are also a laboratory certified by the ISO 9001:2015 standard with a well-established Quality Management System in all processes. We process around 4,000,000 laboratory studies and treat approximately 500,000 patients per year, thanks to the constant support of the General Directorate, the Medical Coordination Directorate and the Diagnostic and Treatment Support Directorate. In addition, we support the different committees of the institution in carrying out the research projects of the different services of both the federal budget and the pharmaceutical industry, such as: antimicrobials, detection and control of nosocomial infections, institutional control and performance, among others. We also actively participate in medical education since there are inter-institutional agreements with the different universities serving around 300 medical students a year.

Central Laboratory structure

The Central Laboratory is made up of 10 sections: (1) Sampling, in charge of the QFBT. Javier Sánchez Mejia and Biol. Rodolfo Sandoval Guzmán, who provide personalized care to adult and pediatric outpatients who come to the laboratory. Through a digital system with barcodes which allows the correct identification and compliance with international patient safety goals; (2) Parasitology, by TEQAC. Beatriz Álvarez Lara, where the studies of the stool and coproparasitoscopic examination of feces are carried out. Recently, the immunological fecal occult blood test was performed, favoring specificity in the determination of the test; (3) Clinical Biochemistry, in charge of the M en C. Leonardo Fermín Acevedo Olvera where about 30 different analytes are performed per patient, glucose tolerance curves, gynecological screening and recently the addition of the glycated hemoglobin test by high-performance liquid chromatography; (4) Bacteriology, in charge of the QBP. Miguel Ángel Morales Gil, where the identification of bacteria and yeasts is carried out using sophisticated techniques such as mass spectrometry; as well as bacterial susceptibility tests to different drugs; (5) Immunology-Virology, by the QFBT. Oscar Iván Acuña Herrera, performs tests of Virology, Tumor Markers, Hormones, Autoimmunity and recently Flow Cytometry and polymerase chain reaction in real time for HIV and SARS CoV2; (6) Hematology-Coagulation in charge of the QBP. Diana Becerril González where Blood Cytometry, Coagulation Times, LE Cells and search for Hematozoa in Blood are performed; (7) Uroanalysis; by Biol. Emilia Evelia Mendoza Figueroa, is in charge of the analysis of more than 10 chemical parameters of urine and the reading of the urinary sediment in real time with the help of an automated state-of-the-art analyzer; (8) Quality Control, in charge of the MAH and SP. Mariblanca Solís Elías is in charge of monitoring compliance with the procedures and activities necessary for compliance with the internal and external quality control of the aforementioned sections; (9) Serum electrolytes; in charge of the QBP Laura Eréndira López Zaragoza where tests are carried out such as the determination of sodium, potassium, chlorine and calcium in urine, purification of endogenous creatinine and proteins in urine for 24 h; and (10) Emergencies, in charge of the QFB. Dr. Sharone Garduño González performs rapid response tests for hospitalized patients who require our service. The independent automated analyzers in this area give priority in the event of an emergency in the Transplant Unit; as well as the rapid response codes of our hospital: stroke, infarction, mater, red, sepsis, among others.

As a leadership strategy, each section leader has been appointed based on their academic background and professional experience within the service, which ensures that each section provides its service with humanism, efficiency and punctuality. In addition, the staff in his charge is highly qualified to provide the professional and quality service that the medical staff requires and our patients deserve, uninterruptedly. It is important to note that the delivery times of results do not exceed 24 h, 365 days a year. It is essential to comment that the central laboratory has been able to face the challenges of being up to the HGM, and an important challenge we faced was the COVID-19 pandemic and free of charge, where we had the need to replace manual techniques with others of greater sensitivity and specificity, and the prompt and timely implementation of high-performance automated equipment.

Human resources assigned to the Central Laboratory

The foundation of any hospital is made up of the people, caregivers, and support staff directly responsible for patient outcomes and satisfaction levels. In the Central Laboratory, a positive and compassionate work culture is always encouraged, working as a team has allowed us to always issue reliable and timely results to contribute to the diagnosis in the medical care of the patients who come to our beloved hospital. Currently,

our staff consists of 177 people (1 head of service, 33 chemists, 2 biologists, 19 laboratory technicians, 78 laboratory technicians, 1 general practitioner, 24 administrative staff, and 19 workers).

Patient care

Appointment scheduling

To perform laboratory studies on outpatients, quickly and effectively (Fig. 1). The adult patient and/or companion presents' himself at the reception of the Central Laboratory from 8:30 a.m. to 2:00 p.m. from Monday to Friday and in the case of pediatric patients from 10:00 a.m. to 1:00 p.m. from Monday to Friday. The reception staff asks the applicant on the day of the appointment with the doctor, to schedule the date of studies, minimum 15 days before the medical appointment and maximum 30 days, or it will adjust to the dates available in the calendar of the computer system. The staff offers a date to the applicant to find out if the patient can attend the study appointment, if not, another date is proposed. Once the date is agreed, it is captured in the computer system and the patient is provided with their proof of appointment.



Figure 1. Patient care in the Central Laboratory. Outpatient and medical staff reception area (left), outpatient sample waiting room (right).

Sampling

This process is the one with the greatest contact with our patients and we provide them with human warmth and security by having new and sterile material for their procedure. First, the surveillance staff asks the patient and/or companion to go to the reception for the printing of barcode labels for studies requested by the doctor and then to line up for the collection of a sample, which can be blood, parasitological and/or bacteriological. The Central Laboratory professional starts the session through an electronic tablet that is located in each cubicle, entering their username and password and that also registers with barcodes the type of patient, shift, productivity of each phlebotomist, internal folio, the patient's full name, age and sex, thus complying with institutional identifiers and international patient safety goals. Finally, the staff proceeds to take the patient's samples, register them with barcodes and distribute them to the different process areas (Fig. 2).



Figure 2. Blood samples are taken at the Central Laboratory. Barcode identification of biological samples (left), care process in cubicles (right).

Central Laboratory automation

The first step toward optimizing resources and improving efficiency was the centralization of samples in a single Central Laboratory. To this end, a pneumatic sample transport system was implemented, which allows samples to be sent from the different areas of the hospital to the Central Laboratory. This centralization has allowed all samples to be processed in one location, which has facilitated excellent quality control and standardization of procedures. In April 2007, a robotic system for transporting and handling samples known as Power Proccesor was installed for the areas of Biochemistry and Immunology, which has eliminated up to 80% of manual processes, considerably reducing processing times and biological risk for equipment operators. It is important to mention that in the past 4 years, more than 35 high-performance automated analyzers have entered all sections of the Central Laboratory, maintaining the constant commitment to technological



Figure 3. Automation and modernization of the Central Laboratory. Users of the operational area of the different sections (hematology, immunology and bacteriology), respectively.



Figure 4. Advances in diagnostic technology. Bacteriology section of the Central Laboratory where you can see some of the high-performance automated equipment to provide a better service.

innovation and the elimination of obsolete equipment (Figs. 3 and 4). To mention a few, BC Robo 900 equipment with greater capacity in the automatic labeling of tubes was introduced in the sampling area, which minimizes the risk of errors in the identification of patient samples, a critical factor in medical diagnosis. In addition, in the bacteriology section, a comprehensive system has been installed with an automated plate seeder, the highest range of bacterial identification and detection of sensitivity to antibiotics, an instrument with the greatest capacity on the market in the detection of bacterial growth and another more recent in mass spectrometry, generating greater support for timely diagnosis. In recent days, a robotic belt with a greater capacity for the transport and handling of samples known as DXA 5000 fit is in the process of being installed, being the Central Laboratory of our hospital the spearhead of a select group of laboratories in Latin America that can count on this technology.

Future scenario of the service

Definitely, today, there is a constant trend toward innovation and modernization in all work environments. This causes great expectations in all areas since having state-of-the-art technology is key to having better results, whatever the field of work. Laboratories do not escape this trend and in order to be "the laboratory of the future" in addition to the equipment, knowledge and experience of the staff, it is necessary to have adequate spaces, not only in size but also in design and other characteristics. Currently, the direction of personalized medicine allows us to approach the treatment and prevention of diseases based on their genetic and environmental variability and the lifestyle of each person. The implementation of the processes associated with Personalized Medicine and the demand of the population increasingly implies that the professionals of the Central and Peripheral Laboratory of the HGM, face great challenges with increasingly sophisticated automated technologies that are very useful to obtain laboratory results quickly.[2] Accurate and reliable. All this will strengthen the national health system and provide better care to patients from all corners of

our country, prioritizing vulnerable groups. Similarly, the transformation of health systems toward a digital world will have an impact on the way health services are delivered, cost savings and improved efficiency.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical considerations

Protection of human subjects and animals. The authors declare that the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the World Medical Association and the Declaration of Helsinki. The procedures were authorized by the Institutional Ethics Committee.

Confidentiality, informed consent, and ethical approval. This study does not involve personal patient data, medical records, or biological samples, and does not require ethical approval. SAGER guidelines do not apply.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing or creation of the content of this manuscript.

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