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Designing the ideal training program for cardiothoracic surgery in the modern era

Diseñando el programa de entrenamiento ideal para cirugía cardiotorácica en la era moderna

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ABSTRACT

The landscape of cardiothoracic surgery has undergone significant evolution over the past 15 years, driven by advances in minimally invasive techniques, endovascular procedures, robotic technology, and mechanical circulatory support. Consequently, training programs must adapt to prepare residents for the broad spectrum of modern cardiothoracic practice. This article proposes a framework for the ideal hospital and cardiothoracic surgery residency program, emphasizing infrastructure, faculty expertise, and structured rotations that reflect contemporary surgical demands. Pediatric and adult care should be integrated, and conventional surgery, although less frequent in some centers, remains essential.

Keywords: cardiac surgical procedures, education medical graduate, trends, internship and residency, models educational, thoracic surgical procedures.

RESUMEN

El campo de la cirugía cardiotorácica ha experimentado una evolución significativa en los últimos 15 años, influenciada por avances en técnicas mínimamente invasivas, procedimientos endovasculares, tecnología robótica y soporte circulatorio mecánico. Como resultado, los programas de formación deben adaptarse para preparar a los residentes para el amplio espectro de la práctica cardiotorácica moderna. Este artículo propone un marco para el hospital y el programa de residencia ideales en cirugía cardiotorácica, haciendo énfasis en la infraestructura, la experiencia del profesorado y las rotaciones estructuradas que reflejen las demandas quirúrgicas contemporáneas. La atención pediátrica y adulta deben integrarse, y la cirugía convencional, aunque sea menos frecuente en algunos centros, sigue siendo fundamental.

Palabras clave: *procedimientos quirúrgicos cardíacos, educación médica de posgrado, tendencias, internado y residencia, modelos educativos, procedimientos quirúrgicos torácicos.*

The training of cardiothoracic surgeons in the twenty-first century stands at a global inflection point. Accelerated population aging, the escalating burden of cardiovascular disease, and the rapidly expanding technological complexity of surgical interventions have converged to create unprecedented demands on residency programs. These programs must now produce specialists with advanced technical proficiency, sound operative judgment, and a sophisticated understanding of hybrid and minimally invasive therapies.[1] In Latin America –and particularly in Mexico– this need is further magnified by structural inequities in access to cardiac surgery and by marked regional variability in hospital infrastructure.

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International surgical societies have repeatedly emphasized that traditional training models –characterized by inconsistent case exposure and predominantly opportunistic learning– are no longer sufficient to guarantee reliable surgical outcomes or to sustain the growth of the specialty in the coming decades.[2-4] They advocate for standardized curricula, high-fidelity simulation, competency-based evaluation, and early exposure to advanced procedures. Leading programs have already incorporated these elements in an effort to bridge the widening gap between clinical demands and the availability of adequately trained surgeons.[5]

In Mexico, where cardiovascular disease remains the foremost cause of mortality[6] and the supply of specialists is limited, strengthening residency programs represents both a public-health priority and a matter of long-term systemic sustainability. The development of a contemporary Cardiothoracic Surgery Residency requires not only an adequate procedural volume but also the integration of modern educational methodologies, a culture of patient safety, continuous certification, and participation in multicenter learning networks.[7]

This article presents the structure, outcomes, and guiding principles of a current Cardiothoracic Surgery Residency Program in Mexico, designed in accordance with international standards and adapted to local realities. Its purpose is to offer a replicable model that integrates academic rigor, technical competence, and social responsibility—ultimately preparing surgeons capable of meeting the cardiovascular needs of the country in the decades ahead.

THE IDEAL CARDIOTHORACIC SURGERY TRAINING PROGRAM: CORE CHARACTERISTICS

1. **Infrastructure**
   a. Dedicated hybrid operating rooms for endovascular and minimally invasive procedures.
   b. Robotic surgical systems available for daily clinical use.
   c. ECMO and ventricular assist device (VAD) programs with on-site coordination teams.
   d. Pediatric cardiothoracic surgical units integrated within the institution.
   e. Simulation labs equipped for open, endoscopic, and robotic technique practice.

2. **Faculty expertise**
   a. A diverse team of specialized cardiothoracic surgeons:
      - Experts in minimally invasive valve surgery.
      - Robotic surgeons performing routine clinical cases.
      - Endovascular specialists for thoracic aortic pathologies.
      - Pediatric and congenital heart surgeons.
      - Transplant and mechanical circulatory support specialists.

   b. Active research staff supporting academic development and innovation.

3. **Case volume and variety**
   a. High procedural volume across subspecialties to ensure adequate resident exposure.
   b. Balance of elective and emergent cases.
   c. Opportunity to rotate through affiliated high-volume centers if local caseload is limited (especially for coronary artery bypass surgery).

THE MODERN RESIDENCY PROGRAM: PROPOSED ROTATIONS AND STRUCTURE

Two years of general surgery residency prior to cardiothoracic surgery residency

Year 1-2: general surgery residency

Year 3-4: surgical foundations and ICU management
- Dedicated cardiothoracic ICU experience.
- Basic open-heart surgery exposure.

Core adult cardiothoracic surgery
- Conventional cardiac surgery (valves, CABG, aortic surgery).
- Introduction to endovascular techniques.
- Elective rotation in minimally invasive approaches.
- Thoracic non-cardiac surgery.

Pediatric and congenital heart surgery
- Pediatric cardiac ICU.
- Surgical repair of congenital heart disease in infants and children.
- Adult congenital heart disease rotations.

Year 5-6: advanced and minimally invasive techniques
- Robotic cardiac and thoracic surgery.
- Advanced endovascular and hybrid procedures.
- Exposure to transcatheter structural interventions (TAVI, TEVAR).

Transplantation and mechanical circulatory support
- Heart and lung transplantation.
- VAD implantation and ECMO management.
- Elective time for research or sub-specialization.

Academic and professional development
- Structured mentorship for research, publication, and presentation.
- Leadership and communication training.
- Annual surgical skill assessments and simulation labs.

THE MODERN RESIDENCY PROGRAM: PROPOSED ROTATIONS AND STRUCTURE

Direct admission to cardiothoracic residency program

Year 1: surgical foundations and ICU management
- General surgical rotations (vascular, thoracic, trauma).
- Dedicated cardiothoracic ICU experience.
- Basic open-heart surgery exposure.

Year 2-3: core adult cardiothoracic surgery
- Conventional cardiac surgery (valves, CABG, aortic surgery).
- Introduction to endovascular techniques.
- Elective rotation in minimally invasive approaches.
- Thoracic non-cardiac surgery.

Year 3-4: pediatric and congenital heart surgery
- Pediatric cardiac ICU.
- Surgical repair of congenital heart disease in infants and children.
- Adult congenital heart disease rotations.

Year 4-5: advanced and minimally invasive techniques
- Robotic cardiac and thoracic surgery.
- Advanced endovascular and hybrid procedures.
- Exposure to transcatheter structural interventions (TAVI, TEVAR).

Year 5-6: transplantation and mechanical circulatory support
- Heart and lung transplantation.
- VAD implantation and ECMO management.
- Elective time for research or sub-specialization.

Academic and professional development
- Structured mentorship for research, publication, and presentation.
- Leadership and communication training.
- Annual surgical skill assessments and simulation labs.

FINAL COMMENTARY

The development of a contemporary Cardiothoracic Surgery Residency Program in Mexico is not merely a curricular exercise; it constitutes an intentional act of institutional reconstruction—a deliberate stance toward the challenges already shaping the future of our specialty. In a country where the burden of cardiovascular disease continues to rise, where human resources remain insufficient, and where therapeutic complexity grows at an exponential pace, clinging to traditional training paradigms would be, at best, imprudent and, at worst, irresponsible. Our program seeks to break that inertia.

The experience described here demonstrates that it is indeed possible to establish a structured, competency-driven, intensive, and ethically grounded training framework, even within the constraints of the national context. The incorporation of advanced simulation, continuous assessment, early participation in complex interventions, and an explicit emphasis on clinical reasoning, patient safety, and professional maturity are not academic luxuries—they are the minimum requirements for producing surgeons capable of responding to Mexico's cardiovascular realities in the decades to come.

Moreover, this model is not intended as an isolated initiative. It aims to provide a replicable, adaptable, and continually improvable framework for other centers seeking to modernize their training paradigms. The objective is not to prescribe a rigid formula, but to offer a critical reference point that invites reflection, constructive debate, and most importantly, collective action.

Ultimately, surgical training is an intergenerational covenant: what we build today determines who will operate, innovate, and lead tomorrow. If we accept that cardiothoracic surgery in Mexico demands a qualitative leap forward, then this program stands as a deliberate and meaningful first step toward that higher standard. Our commitment is both sober and far-reaching: to train surgeons prepared not only to practice the medicine of today, but to sustain –with rigor, clarity, and excellence– the medicine that is still to come.

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