Innovation in Motion: Robotic Surgery's status in Latin America

Y Rivero-Moreno[1], J Cordova-Guilarte[1], S Echevarria[2], G Dorado-Avila[2], L Pianetti3, J Acevedo-Rodríguez[4], C Chavez-Campos[5], C Vidal-Valderrama[6], M Paz-Castillo-Lopez[1], C Estrella-Gaibor[7], Y Salcedo[8], A Pereda-Gonzales[9], P Guamán-Ludeña[10], W López-Porras[1], F Lott[11]

Abstract

This study aims to describe the present status of robotic surgery (RS) in Latin America. A cross-sectional study was conducted, collecting data from 10 robotic programs in 6 Latin American countries through surveys of surgical specialists and heads of surgical services. The utilization of RS in Latin America exhibits significant variability depending on the specific country and healthcare facilities. This variability encompasses factors such as the annual volume of surgeries, the types of institutions involved, and the primary medical specialties employing this technology. Concerted efforts within the region to augment scientific research output about robotic procedures are imperative.

Keywords: Robotic Surgical Procedures, Latin America.

Authors addresses: [1]Universidad de Oriente, Venezuela. [2]Universidad Mayor de San Simón, Cochabamba, Bolivia. [3]Universidad Nacional del Litoral, Argentina. [4]Tecnológico de Monterrey, México. [5]Universidad Peruana de Ciencias Aplicadas, Perú. [6]Universidad Autónoma de Baja California, Baja California México. [7]Hospital Esmeraldas sur Delfina Torres de Concha, Ecuador. [8]Universidad Iberoamericana, Santo Domingo, República Dominicana. [9]Facultad de Medicina-Universidad de Panamá. [10]Hospital Carlos Andrade Marín, Ecuador. [11]Brazilian National Cancer Institute, INCA, Rio do Janeiro, Brazil.

Corresponding Author: Yeisson Rivero-Moreno. Universidad de Oriente, Venezuela. 112 Rockaway Avenue, Brooklyn, New York 11233, United States.
Email: Yeissonmbi@hotmail.com

Introduction

Medicine has been revolutionized by Robotic surgery (RS), a type of minimally invasive surgery that uses advanced robotic technology to assist surgeons with performing highly complex surgical procedures. This cutting-edge technology allows for greater precision, ease, control, and flexibility during surgery, resulting in less pain, scarring, and faster recovery times for patients (1).

The first RS was performed in 1985 when an arm-robot was used to perform a neurosurgical biopsy. In the 1990s, however, this technology began to gain popularity. In 2000, the da Vinci Surgical System was approved by the FDA for use in laparoscopic surgeries. Since then, it has continued to evolve and is now used in a wide range of surgical specialties and procedures (2).

The da Vinci Surgical System, which is the most widely used RS system in the world, has been used for prostatectomies, hysterectomies, coronary arteries bypass, mitral valve replacement, and colorectal surgeries, among others. The system consists of four robotic arms, one of which holds a camera, while the other three hold surgical instruments. And during surgery, the physician controls the arms from a console, which provides a 3D view of the operating site (3).

The robotic arms used in the surgery can move in ways that are not possible with human hands, allowing for more accurate incisions and sutures. This results in less trauma to the patient's body and faster recovery times and reduced procedural complications. In addition to its medical benefits, RS has economic benefits. Because it is a minimally invasive procedure, patients can return to work and other activities more quickly than with traditional surgeries. This can result in lower healthcare costs and increased productivity (4).

In Latin America, the use of RS began in 2005 in Argentina, where surgery was performed on a patient suffering from achalasia. It was followed by Brazil, Mexico, Argentina, Colombia and Venezuela. Since then, it has become increasingly popular in the region, and nowadays the former has more than 100 robotic surgical units in the nation (5).

However, despite its potential, compared with developed countries the use of this technology and research in its field is not widely spread in Latin America. This knowledge gap not only limits the adoption of this technology but also hinders the development of best practices and guidelines specific to the region. Therefore, by conducting a study in this demographic area, we can gain a better understanding of the current situation and uses of RS, identify any barriers to its implementation, and develop strategies to overcome them.

Methodology

A cross-sectional study was carried out to characterize the current situation of RS in Latin America. The information was collected through surveys of surgical specialists and heads of surgical services of private and public health centers which count with the technology. Data from 10 robotic programs in 6 countries were finally gathered in May 2023. Previous studies were considered as a reference for the design of the survey used, which requested information regarding the start of the programs, the number and kind of robots used as well as their durability, the number and kind of surgeries done, the use of the robots for educational programs, and robotic program interruptions and reasons. Furthermore, an exploratory analysis was performed to compare total surgeries, percentage of urologic surgeries, and total months of operation between private vs. public center programs using the U-Mann-Whitney test.

Results

The general characteristics of the programs studied are summarized in Table 1. These programs correspond to only some of the centers with such technology within their respective country; only in the case of Panama was it possible to collect data from all the centers with surgical robots existing in the country. In the case of the Dominican Republic, the country only had two programs, the one described in Table 1 and one in the "Abreu Clinic", a private medical center that will begin interventions with one da Vinci robot in June 2023. Also, it is important to notice that six of the ten programs were from Panama and Venezuela.

The distribution of the use of RS for the different specialties was heterogeneous in this sample, as shown in Figure 1. The National Cancer Institute of Brazil was the only one to use RS in specialties of thoracic and head and neck surgery. Meanwhile, only the Ecuadorian center performed robotic interventions for pediatrics, and Venezuelan centers performed exclusively urology procedures.

Type of institutions

Six of the programs studied correspond to private health centers and four to public institutions. It was found that in private institutions the percentage of urological surgeries was higher with a statistically significant difference (p 0.016). Two-thirds of the total procedures recorded in this study were performed in private health centers and the median number of months that the programs were functioning was higher in public hospitals.

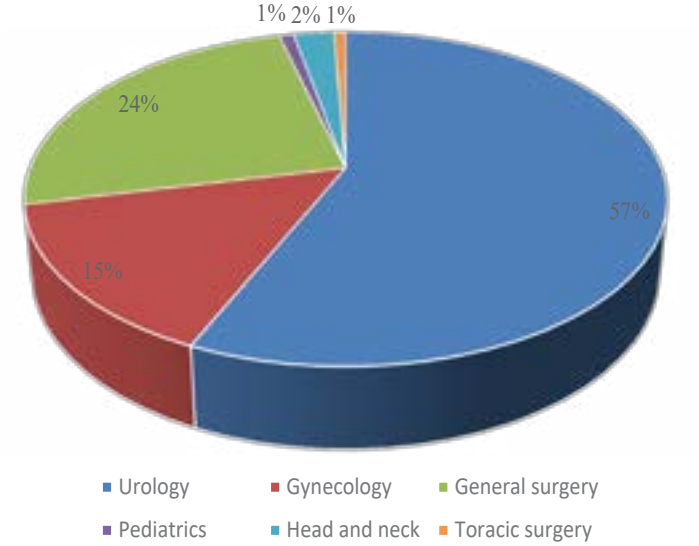

Figure 1 Percentage of Procedures by Speciality.

Table 1 Characteristics of robotic surgical programs in Latin America.

Country	Brazil	Venezuela	Venezuela	Mexico	Panama	Panama	Panama	Panama	Dominican Republic	Ecuador
Name of the center	National Cancer Institute	Instituto Medico La Floresta	Centro Médico Docente "La Trinidad"	Hospital Del Prado	Hospital Pacifica Salud	Hospital Nacional	Ciudad de la Salud	The Panama Clinic	Hospital Metro-politano de Santiago	Hospital Carlos Andrade Marín
Type of health center	Public hospital	Private clinic	Private clinic	Private clinic	Public hospital	Private clinic	Public hospital	Private clinic	Private clinic	Public hospital
Starting year of the program	2012	2009	2021	2014	2021	2012	2023	2020	2014	2015
Number of robots	1	1	1	1	1	1	2	1	1	2
Number of surgeries performed by specialty	**1384**	**784**	**101**	**289a**	**316**	**1750**	**7**	**360**	**5200**	**2568**
Urology	425	784	101	126	88	700	1	188	4300	516
Gynecology	318	-	-	24	218	150	2	71	200	914
General surgery	300	-	-	139	10	900	4	101	700	968
Pediatrics	-	-	-	-	-	-	-	-	-	112
Head and neck	310	-	-	-	-	-	-	-	-	-
Thoracic surgery	31	-	-	-	-	-	-	-	-	58
Years of functioning	9,75	10	2	9	2	11	0	2,58	9	7
Number of cases per year	141,9	78,4	50,5	32,1	158,0	159,1	7,0	139,4	577,8	366,9
% Urology cases	30,7	100,0	100,0	43,6	27,8	40,0	14,3	52,2	82,7	20,1

a The cases correspond only to those carried out during 2023

b It was calculated, excluding the number of months that the programs were interrupted.

Program interruptions

Interruptions were recorded in 5 of the 10 programs studied. In two cases, it was due to the pandemic and mandatory isolation due to COVID-19, such are the cases of the private hospital "The Panama Clinic" and the public hospital "Carlos Andrade Marín" for 5 and 12 months, respectively. The remaining centers, the lack of equipment materials, and the failure in their operation have been the main reasons for suspension. The National Cancer Institute of Brazil temporarily ceased its program for 15 months due to the lack of material for its equipment, as well as the private hospital "Del Prado" of Mexico for an unspecified time. In the case of the private hospital "Instituto Médico La Floresta" of Venezuela, the temporary suspension of the program was due to the complete failure of the equipment for 48 months.

Equipment functioning

Only 2 of the institutions had 2 operating robots, both institutions were public. All the centers used the da Vinci system except for 2 centers in Panama that used the Hugo Ras system. In three of the centers, new robots have been added, 2 to replace the previous non-functional ones and 1 to add additional equipment. The number of robots did not correlate to the number of procedures. Although the public hospital "Carlos Andrade Marín" of Ecuador had two Da Vinci robots, it presents a lower number of procedures (2566) concerning other institutions such as the private hospital "Metropolitano de Santiago" of the Dominican Republic that had one Da Vinci robot and has performed 5200 procedures so far.

Upcoming projects in Latin America

Other countries, such as Chile, Argentina, and Uruguay, that have RS programs could not be contacted to obtain information from their programs for this study.

As robotic surgery becomes more widely available, many hospitals and medical facilities in Latin America will continue to use it. However, depending on circumstances like the availability of qualified surgeons, the cost of the technology, and the overall healthcare infrastructure in each nation, it can affect how quickly this technology is adopted. For example, thanks to the CDD Global Group and Abreu Clinic, the Dominican Republic may incorporate an additional robot into the country, which will be available in the second half of 2023 (6).

Unfortunately, other countries, such as Chile, Argentina, and Uruguay, that have robotic surgery programs could not be contacted to obtain information from their programs for this study. For the rest of the nations including Costa Rica, Haiti, El Salvador, Bolivia, Paraguay, Guatemala, Nicaragua, and Honduras, there have been speculations, but no concrete plan has been implemented.

Discussion

The description of robotic surgical programs in this study complements the continent's efforts to expand the information available on RS. Few studies have described cases of RS interventions from several countries simultaneously, as was performed by Autorino et al, who gathered information of robotic simple prostatectomies from several centers in Europe and America, including Venezuela, Brazil, and Chile (7). Furthermore, even fewer studies have presented information regarding RS exclusively in Latin American a region with potential growth in this field. Moldes et al. gathered information through surveys, of all the robotic surgical programs from 4 countries (Brazil, Chile, Argentina, Uruguay), but center just in urology (8).

Similarly, Secin et al have focused on the description of cases from some programs within some countries. They described 10 RS programs from 6 countries (Brazil, Argentina, Uruguay, Venezuela, and Mexico). In our study, we were able to include additional information from centers in the Dominican Republic and Panama, which had not been described before (9).

Urology is the main field of application of robotic surgery since it was conceived. Today, nine out of ten urology departments use RS to varying degrees, and four university departments always perform robotic-assisted surgery as a starting point (10). Accordingly, in this study more than half of the interventions were in urology. However, in a series of 500 cases of RS interventions in a private center in Mexico in order of frequency according the specialty, the three most performed surgeries were radical prostatectomy (53.8%), followed by hysterectomy (12.8%) and inguinoplasty (6.6%) (11). Although in our study it was not specified the exact surgical intervention performed, the order of frequencies by specialties was similar but with more interventions of general surgery than gynecology.

It was also recorded the use of RS in other specialties such as thoracic surgery, little described in the region. While in our study less than 100 cases were identified, the study from Buitrago et al. reported in detail 220 cases of robotic-assisted video thoracoscopic surgery from 3 centers in Colombia (12).

Although, pediatric specialties are in the process of making and implementing robotic programs supported by the evident development in adult specialties. Nevertheless, due to the wide social, economic, and technological gap between hospitals in South America, it is hard to develop a proper pediatric RS program (8). As a sample, in this study pediatric represented only 4.4% of the total cases and all from one center. A similar situation was found by Secin et al. where only 2 of the 10 programs described interventions in pediatrics (9).

However, several studies focused specifically on this field. For example, Arellano et al. reported 147 pediatric patients that underwent robot-assisted laparoscopic and thoracoscopic surgery in Mexico (13). The setting is similar for head and neck surgery, where most of the studies published are case series (14).

Robotic technology has important implications in the field of surgical teaching and training. It allows to execution of procedures in virtual reality or simulated environments without risk or harm to patients. It also performs quantitative measurements on the learning curve, establishing objective parameters to specifically assess skills and abilities (15). In LA some studies have included the learning curves when using robotic equipment, reflecting the training effort in the region (16).

Although training in surgery depends entirely on the number of operable cases available at the time, the training time, and compromises patient safety. RS will become a new means to acquire the necessary skills to operate, thanks to the simulation of all the interventions that can be performed with the robot. Nowadays surgeons can use surgical robots to practice operations with three-dimensional virtual reality simulators, and soft tissue models that recreate the texture of human tissues through force feedback systems (touch or haptics technology refers to touch or tactile sensation) (17). In LA little has been mentioned regarding the use of this technology for training. Nonetheless, this purpose seems to be quite extensive as suggested by our sample where 7 of 10 programs were involved in postgraduate and subspecialty training formation.

Regarding the type of institutions, unlike the series of programs described by Secin et al, in this study most centers were private. Although, there is no systematic review that gathers information concerning the type of institutions with RS, most of the reports reviewed correspond to a series of private centers (11,12,18).

Program interruptions were also evaluated. Similar to Secin et al. study, where half of the institutions had their programs temporarily or definitively interrupted mainly due to the high costs of disposable

instruments, in this study the proportion was the same and the reasons also included the COVID-19 pandemic.

Only after Intuitive's (Intuitive Surgical, Sunnyvale, CA) patent ended in 2019 different brands and models of robotic platforms were released worldwide. In this scenario, RARP with HugoTM RAS System (Medtronic, Minneapolis, USA) was approved in 2021 by the Panama healthcare regulatory agency (Ministry of Health, Minsa) for clinical use in urologic procedures. This multiport platform has some modifications compared to the conventional da Vinci (Intuitive Surgical, Sunnyvale, CA) consoles. The arms are placed in separate karts for independent docking, while the console provides an open design with a 3D screen visualized by the 3D glasses used by the surgeon.

However, due to the recent release of HugoTM RAS in the market, the literature still lacks studies describing the performance of this robot in clinical settings. [19] Only 1 study was found on the use of the Hugo RAS system in cases in Latin America, specifically in Brazil where Alfano et al. report the clinical data of patients who underwent Robotic-assisted Radical Prostatectomy and concluded that safe and feasible procedures were performed with this system (20).

The utilization of robotic surgical procedures is currently prevalent across various Latin American countries; however, its implementation exhibits significant variability depending on the specific country and healthcare facilities. This variability encompasses factors such as the annual volume of surgeries, the types of institutions involved, and the primary medical specialties employing this technology. It is worth noting that there is a lack of national associations in the region responsible for systematically gathering data on robotic surgery within each country, and only a limited number of studies have sought to characterize the extent of its utilization on a national level. Consequently, concerted efforts within the region to augment scientific research output about robotic procedures are imperative. Establishing associations akin to a "Latin-American society of robotic surgery" would serve as an intriguing initial step towards spearheading these endeavors, following the example set by comparable organizations in the United States and Europe.

CONFLICTS OF INTEREST: The authors of this study do not report any conflict of interest.

References

1. Moretti TBC, Miyaoka R, Neto WA. Robotics and the Avant-Garde Role of Urologic Surgery. In: Bezerra da Silva Junior G, Nangaku M. ***Innovations in Nephrology: Breakthrough Technologies in Kidney Disease Care***. Springer International Publishing; 2022 p. 399–420.
2. Shah J, Vyas A, Vyas D. The History of Robotics in Surgical Specialties. ***American Journal of Robotic Surgery*** 2014;**1(1)**:12–20.
3. Ng ATL, Tam PC. Current status of robot-assisted surgery. ***Hong Kong Medical Journal*** 2014;**20**:241–50.
4. Ho C, Tsakonas E, Tran K, Cimon K, Severn M, Mierzwinski-Urban M, et al. ECONOMIC ANALYSIS. In: ***Robot-Assisted Surgery Compared with Open Surgery and Laparoscopic Surgery: Clinical Effectiveness and Economic Analyses***. Canadian Agency for Drugs and Technologies in Health; 2011.
5. Cornejo-Aguilar JA, Cornejo J, Vargas M, Seb astian R. The revolution of robotic surgery in latin america and the future implementation in the healthcare system of Peru. ***Rev Fac Med Humana*** 2019;**19(1)**:5–5.
6. Resumen de Salud. Clínica Abreu anuncia tecnología robótica. [Internet]. 2023 [cited 2023 Jun 15]. Available from: https://resumendesalud.net/clinica-abreu-anuncia-tecnologia-robotica-video/
7. Autorino R, Zargar H, Mariano MB, et al. Perioperative Outcomes of Robotic and Laparoscopic Simple Prostatectomy: A European–American Multi-institutional Analysis. ***European Urology*** 2015;**68(1)**:86–94.
8. Moldes JM, de Badiola FI, Vagni RL, et al. Pediatric Robotic Surgery in South America: Advantages and Difficulties in Program Implementation. F***rontiers in Pediatrics*** 2019;**7**:94.
9. Secin FP, Coelho R, Monzo Gardiner JI, et al. Robotic surgery in public hospitals of Latin-America: a castle of sand? ***World Journal of Urology*** 2018;**36(4)**:595–601.
10. Jølner M, Brignone J, Fabrin K, Rawashdeh YF, Lund L. [Robotic surgery used in urology]. ***Ugeskr for Laeger*** 2022;**184(36)**:V01220011.
11. Vásquez-Lastra C, Decanini-Terán C, Maffuz-Aziz A, et al. Cirugía robótica en el Centro Médico ABC: experiencia en los primeros 500 procedimientos realizados. ***Gac Med Mex***. 2021;**157**:188-193
12. Buitrago MR, Restrepo J. Robot-assisted thoracic surgery in Colombia: a multi-institutional initial experience. ***Annals of Cardiothoracic Surgery*** 2019;**8(2)** :233–40.
13. Navarrete Arellano M, Garibay González F. Robot-Assisted Laparoscopic and Thoracoscopic Surgery: Prospective Series of 186 Pediatric Surgeries. ***Frontiers in Pediatrics*** 2019;**7**:200.
14. Cadena E, Guerra R, Pérez-Mitchell C. Bilateral vallecular cyst: transoral robotic resection. ***Journal of Robotic Surgery*** 2018;**12(2)**:369–72.
15. Moreno-Portillo M, Valenzuela-Salazar C, David Quiroz-Guadarrama C, Pachecho-Gahbler C, Rojano-Rodriguez M. Robotic surgery. ***Gaceta Medica de Mexico*** 2014;**150**:293–7.
16. Castilo C OA, López-Foantana G, Rodríguez-Carlin A, Landerer L E, Vidal-Mora I, De Orúe-Ríos MA, et al. Prostatectomía radical asistida por robot da Vinci: experiencia inicial en 50 casos consecutivos. ***Revista Chilena de Cirugia*** 2011 Dec;**63(6)**:609–16.
17. Valero R, Ko YH, Chauhan S, et al. Robotic surgery: History and teaching impact. ***Actas Urologicas Espanolas*** 2011;**35(9)**:540–5.
18. Castillo OA, Rodríguez-Carlin A, López-Fontana G, Vidal-Mora I, Gómez I R. Nefrectomía parcial robótica: experiencia inicial en 25 casos consecutivos. ***Actas Urologicas Espanolas*** 2012;**36(1)**:15–20.
19. Alfano CG, Moschovas MC, Montagne V, Soto I, Porter J, Patel V, et al. Implementation and outcomes of Hugo(TM) RAS System in robotic-assisted radical prostatectomy. **International Brazilian Journal of Urology** 2023;**49(2)**:211–20.
20. Favorito LA. HUGO(TM) RAS System in Robotic-Assisted Radical prostatectomy is highlighted in International Brazilian Journal of Urology. ***International Brazilian Journal of Urology*** 2023;**49(2)**:172–4.