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CORRESPONDENCE

The experience with Hugo™ robot-assisted surgery on complex gynecological patients in Panama

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Abstract
The Hugo™ robotic assisted surgery system is a relatively new robotic platform developed by Medtronic. The study objective was to describe the experience of using Hugo™ robotic assisted surgery in gynecological surgeries and compare robotic assisted surgery-related outcomes between complex and non-complex gynecological patients at the Pacifica Salud Hospital. We performed secondary data retrospective analysis of 144 consecutive patients who underwent gynecological surgery with Hugo™ robotic assisted surgery system (Medtronic) at the Pacifica Salud hospital in Panama City from July 19, 2021, to August 3, 2023. Complex patients were defined as those with one or more risk factors for surgery complications. Descriptive analysis of participants' sociodemographic and robotic assisted surgery-related characteristics. Due to the non-normal distribution of the RAS-related numeric variables, we compared these variables between complex and non-complex cases of gynecological patients using Kruskal–Wallis's test. The study found that Hugo™ robotic assisted surgery system was safe for gynecological surgery in patients with and without risk factors for developing major surgery complications. None of the patients experienced any complications, and they had short hospital stays with low blood loss without requiring a blood transfusion. The Hugo™ robotic assisted surgery system was technically sound and did not present technical failures. The results could be a reference for adopting this technology and developing best practices in the Latin American region.

Keywords Hugo™ robot-assisted surgery · Gynecology · Complex patients · Panama

Background

Robot-assisted surgery (RAS) is a minimally invasive procedure that aims to enhance dexterity, visualization, and surgical precision to minimize surgical trauma, reduce intraoperative blood loss, surgery-related complications postoperative pain, shorten hospital stays, accelerate patients' recovery, and reduce surgeons' fatigue by improving ergonomics [1]. Since the benefits outweigh the risks, RAS has been spreading fast to operate benign and malignant pathologies and accounts for nearly seventy surgical uses among various specialties, including urology, gynecology, thoracic surgery, and general surgery [1]. Its integration allows innovative approaches such as telesurgery and real-time guidance of new surgeons to overcome geographical and human resource barriers, increase quality and safety, and reduce inequity in access to surgical care [2]. However, minimally invasive surgeries still represent less than 3% of surgeries worldwide.

RAS expansion is especially notorious in high-income countries, with the United States accounting for 70.6% of global RAS volume [3]. In contrast, in the global south, the RAS adoption is slow due to the high cost of this technology and scarcity of surgeons, as these countries account only for 19% of all surgeons worldwide [4].

Despite the budgetary and surgeons' limitations, Latin America and Caribbean (LAC) regions are keeping up with the upward trend of robotic surgery. The RAS market in LAC is projected to grow at a compound annual growth rate of 22% between 2022 and 2027, with a market volume estimated at US$2.62 billion by 2027. Over 50% of the existing RAS systems in LAC have been acquired in the last 5 years. A recent analysis including Brazil, Venezuela, Mexico, Panama, the Dominican Republic, and Ecuador reported the growing tendency of robotic surgery in these

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countries, mainly in urology, gynecology, and general surgery [5].

Panama is also acquiring RAS technology at a fast pace. It is an upper middle-income country with the highest per capita income in Latin America; its Human Development Index is 0.82, and 77.1% of its population has social security [6]. This country has shown robust post-pandemic recovery, with a projected gross domestic product growth rate of 4% for 2024 [7]. Economic stability and increasing demand for quality medical services drive the steady progress and growth of the private health sector that continues investing in advanced medical equipment and facilities. The availability of robotic surgical programs is increasing in this country. Three private hospitals have one robot each—Hospital Pacifica Salud, Hospital Nacional, and the Panama Clinic—and one public hospital, "Ciudad de la Salud," has two robots.[5] Panama has 4,337,668 people, meaning the country has a 1.1 RAS system per 1,000,000 people. As a point of comparison, European countries have 1.8 RAS systems per 1,000,000 people.

RAS is an evolving field, continuously introducing and testing novel robotic surgical platforms. The Hugo™ RAS system is a relatively new robotic platform developed by Medtronic. The Hugo™ RAS system includes a system tower, four independent arm carts equipped with surgical instruments, six different joints for a wider maneuver range, a surgical console with two "pistol-like" arm controllers and a footswitch panel to control the camera, energy sources, the reserve arm, and a high-definition 3D vision system that provides a magnified view of the surgical site [8]. In 2021, the Red de Salud UC Christus in Chile acquired the Hugo™ RAS system to support a novel robotic surgery teaching program [9]. Brazil's initial experience with Hugo™ RAS system was published on 15 patients who underwent transperitoneal robotic assisted radical prostatectomy. All procedures were safe and had acceptable perioperative outcomes without conversions or major complications [10]. In 2021, the Panama Ministry of Health approved the Hugo™ RAS system for clinical use. Afterward, the private tertiary care hospital *Pacifica Salud* became the first in Panama and Central America to perform RAS surgery with the new Hugo™ RAS system.

Gynecologic conditions pose a significant threat to women's health and well-being worldwide [11]. Recently, a considerable shift towards minimally invasive gynecological surgery has been made [12–14]. RAS gynecological surgeries have demonstrated a relatively low risk of developing surgery-related complications compared to open surgeries [15, 16]. It significantly decreases hospital stay and "surgeon-declared" blood loss compared to laparoscopic surgery [10]. The risk for major complications related to minimally invasive gynecological surgeries is higher in complex cases, which comprise older women, those with morbid obesity, hypertension, previous pelvic or abdominal surgery, or repeated cesarean sections, pelvic adhesion syndrome, high uterine weight, and those who undergo complex surgery, including hysterectomy, myomectomy or surgery for malignancy [17–22].

Due to its novelty, the Hugo™ RAS system requires additional evidence of its safety and surgeons' experiences when managing complex gynecological cases with risk factors for major surgery-related complications associated with minimally invasive surgeries. Therefore, this paper aims to describe the experience of using Hugo™ RAS in gynecological surgeries and compare RAS-related outcomes between complex and non-complex gynecological patients at the Pacifica Salud Hospital.

Materials and methods

We performed secondary data retrospective analysis of 144 consecutive patients who underwent gynecological surgery with Hugo™ RAS system (Medtronic) at the Pacifica Salud hospital in Panama City from July 19, 2021, to August 3, 2023.

Study setting

Pacifica Salud Hospital is a private tertiary care hospital in Panama City. It is accredited by the Joint Commission International and affiliated with Johns Hopkins Medicine International. The hospital has 76 beds and offers 31 health services, including general surgery, thoracic, plastic, vascular, urological, and gynecologic surgery. In 2022, the hospital had 4,808 discharges; in 2023, it had 5,100 discharges. The average hospital stay was 2.6 in 2022 and 2.8 in 2023.

Study population and selection criteria

The study included patients aged > 18 who underwent gynecological surgery with the Hugo™ RAS system and had complete surgical time data registered. We collected information on patients operated by three RAS-trained surgeons.

The surgeons received 6 h of theoretical training and 52 h of simulation-based and robotic console training at the University of Illinois Simulation Center, sponsored by Medtronic.

We included all (n = 152) patients operated by these three surgeons and excluded 8 patients (5.2%) from the analysis due to the missing data on surgical time and other variables.

Source of information

Clinical and surgical data were gathered from the patient's medical records and added to an anonymized electronic database.

HUGO™ RAS procedure

The surgeries with Hugo™ RAS system were performed through four abdominal ports, which were: a 11 mm umbilical port, 8 mm right and left auxiliary ports, and an 11 mm auxiliary port. The 11 mm auxiliary port provided the second surgeon with additional assistance during surgery, facilitating the introduction of sutures and endocavitary bags. The robotic arms were connected using a systematic 7-step technique. A 0º optical lens with two lenses was used for the umbilical port. Monopolar scissors were used for dissection at the right accessory port. Fenestrated bipolar forceps were used for vessel sealing at the left accessory trocar; and a needle holder was utilized for suturing.

The placement of the 8 mm ports was determined based on the patient's body weight, as follows: 110–115 lb (50–57 kg) distance 12–13 cm; 116–165 lb (53–75 kg) distance 14–16 cm; 170–200 lb (77–91 kg) distance 17–18 cm; 201 lb (> 92 kg) and above 19–22 cm.

The 11 mm auxiliary port was typically positioned 10–11 cm from the umbilical port, at the Palmer point, ensuring that it is at least 5 cm away from the costal margin. When performing sutures, the needle holder was placed on the robotic right arm; however, the final placement was at the surgeon's discretion, depending on their dominant hand.

Ethical considerations

The study protocol obtained Institutional Review Board approval (N#2586). All patients who underwent surgery with Hugo™ RAS system gave written informed consent for robotic surgery and were personally informed by the operating surgeon about the surgical procedure and its possible complications.

Study variables

Preoperative characteristics of the study population comprised age (years), body mass index (BMI, kg/m^2), medical history, including comorbidity (hypertension, diabetes, anemia), history of previous surgeries (abdominal/pelvic surgeries, twice or more cesarean sections, and surgery indications (myomatosis/leiomyomas, endometriosis, adenomyosis, adhesions, ovarian cyst/benign ovarian mass, abnormal uterine bleeding, fibromatosis and gynecological cancer). We also collected information on the uterus weight (gr) registered in the health record.

RAS-related variables included the year of surgery, type of surgical procedure (hysterectomy, myomectomy, oophorectomy, other), surgery-related times (installation time and surgical time defined as the interval from the first skin incision to the closure of the last skin incision), estimated intraoperative blood loss (ml), and length of hospital stay (days). The length of stay was calculated from the day of hospital admission to discharge. Intraoperative complications were defined as bowel, bladder, ureteral, or vascular injuries that could have happened during the surgery [15]. Postoperative clinical data were collected until the patient's discharge, and postoperative complications were classified according to the Clavien–Dindo classification [23].

We also calculated the following risk factors for surgery complications of each patient: advanced age (≥ 65 years), having one or more chronic non-communicable diseases (NCDs), such as extreme obesity (BMI ≥ 40 kg/m2), hypertension, or diabetes; uterus weight > 500 gr, history of previous surgeries (abdominal/pelvic surgeries), and/or two or more cesarean sections, pelvic adhesion syndrome, current surgery of gynecological cancer, hysterectomy and/or myomectomy. Complex patients were defined as those with one or more risk factors for surgery complications identified through the literature review [17–22].

Statistical analysis. We conducted a descriptive analysis of participants' sociodemographic and RAS-related characteristics. We used percentages for categorical variables, mean and standard deviation for numerical variables with normal distribution, and median with range (min and max values) for non-normal data, verified through the Shapiro–Wilk test.

Due to the non-normal distribution of the RAS-related numeric variables, we compared these variables between complex and non-complex cases of gynecological patients using Kruskal–Wallis's test. The p-value < 0.05 was considered statistically significant. The analysis was performed using Stata V.14.0 statistical software.

Results

The analysis included 144 women who underwent gynecological RAS. The preoperative characteristics of the study population are presented in Table 1. The participants' median age was 44 years (range 20 to 91 years). Only 5.6% were aged 65 years or older. The median BMI was 26 kg/m^2 (range 18 to 52 kg/m^2), and 6.2% had extreme obesity. About 24% had NCDs comorbidity, with hypertension (7.6%) and diabetes (2.8%) being the most common; 16.7% had undergone multiple cesarean sections, and 15% had previous abdominal or pelvic surgery.

The preoperative diagnoses were as follows: myomatosis/leiomyomas/fibromatosis (66.7%), pelvic adhesion syndrome (20.1%), endometriosis (17.4%), adenomyosis (16.7%), ovarian cyst/benign ovarian mass (13.2%), abnormal uterine bleeding (12.5%), and gynecological cancer (4.9%). Approximately, 38% of participants had multiple indications for surgery. The median uterus weight was 140 g (range 44 to 1014 g), and 2.1% had a uterus weighing ≥ 500 g.

The surgical procedures performed were hysterectomy (72.2%), myomectomy (13.9%), oophorectomy (5.6%), and other (8.3%). When considering the risk factors that could lead to major minimally invasive surgery complications, only 5.6% of the women did not have any of these risk factors. In comparison, 42.4% had one risk factor, 36.1% had two, and 15.9% had three or more risk factors.

Table 2 provides information about RAS performance for both complex and non-complex patients. Minor collisions occurred between the robotic arms when performing specific maneuvers outside the usual surgical technique, especially in surgeries with 4 robotic arms. These collisions did not disrupt the surgical procedure or result in any equipment damage or harm to the patient. The median installation time was 2 min (range 1 to 17). The median surgery time was 91 min (range 41 to 250 min). The median estimated blood loss was 25 ml, ranging from 5 to 120 ml, and the median hospitalization time was 2 days (range 1–3 days). The comparison of patients with one, two, and three or more risk factors with non-complex patients did not reveal any statistically significant differences (Tables 2 and 3). All surgeries were safe, with no intraoperative complications. Only one minor complication was reported in the first 30 days post-surgery: this was an open wound in the left port after 2 weeks, which was secondary to a small seroma. This condition was effectively managed on an outpatient basis with antibiotics and topical treatment. Follow-up assessments confirmed the complete healing of the wound, and the patient did not require hospitalization.

Discussion

The study results show that the Hugo™ RAS system was safe for gynecological surgery. From the clinical outcomes' perspective, none of the patients with and without risk factors for developing major surgery complications developed any trans- or postoperative complications, and the length of hospital stay was short. The Hugo™ RAS system was technically sound, the duration of the surgery from start to finish was within the expected parameters. Blood loss was low, and it did not require a blood transfusion, and the tasks were performed with precision and accuracy with only rare minor collisions that did not disrupt the surgical procedure or result in equipment damage or harm to the patient.

Patients with risk factors that could lead to major surgery complications are more common due to the growing increase in chronic non-communicable diseases [24]. These health problems make minimally invasive surgeries more challenging technically and increase the risk of surgery-related complications. For instance, patients with NCDs have a compromised immune system that increases the patient's susceptibility to infections post-surgery, which in turn increases the length of hospital stay; patients with diabetes have poor wound healing due to compromised circulation and high blood sugar levels; patients with cardiovascular or respiratory conditions have increased anesthetic risks. Therefore, it is relevant for surgeons to conduct preoperative risk assessments and engage in shared decision-making with patients by explaining RAS's benefits, harms, and risks [25].

The present study aligns with the findings of previous studies testing the Hugo™ RAS system in gynecology, which reported that it offers significant advantages in precision, safety, and recovery time and requires a short hospital stay [16]. This is particularly important since surgical complications can lead to unexpected health-related expenses, which can be financially burdensome for patients and their families.

In Panama, 99% of RAS surgeries are performed by the private sector [5], thus confirming the speed with which the private sector in this country can adopt, adapt, and use the new technology compared to the public sector. Latin America and the Caribbean's public and private healthcare sectors face significant disparities in adopting safe state-of-the-art health technology. Approximately, 80% of robotic assisted surgery systems are in private facilities, with only 20% in public hospitals [5].

The lack of integration of new technology widens the gap in access to modern technology for the population. The size of this gap can lead to negative consequences in terms of access barriers and out-of-pocket expenses for the population. This is because public healthcare systems provide services to over 65% of the population in LAC countries, but these healthcare systems have a limited capacity to upgrade their technology. For instance, in Panama, the out-of-pocket health expenditure is 32% of the total health expenditure [26]. This figure signals a substantial use of private healthcare services. It underscores the need for better financial protection mechanisms to ensure the necessary medical services, including modern technology, are accessible without causing economic strain.

Due to its novelty, HUGO RAS still has limited information available about its effectiveness and costs compared to other robotic systems on the market. However, studies comparing the daVinci and HUGO RAS surgical platforms have shown no differences in surgical and functional outcomes for radical prostatectomy [27]. At the same time, HUGO RAS provided an 11% cost saving for this surgery compared

Table 1 Preoperative characteristics of the study population, type of surgical procedure, and number of risk factors for surgical complications

	Total $n=144$
Age, median (min–max)	44 (20–91)
Age group ≥ 65 years, n (%)	8 (5.6)
Body mass index, kg/m^2, median (min–max)	26 (18–52)
Medical history	n (%)
Hypertension	11 (7.6)
Extreme obesity (BMI ≥ 40 kg/m^2)	9 (6.2)
Diabetes	4 (2.8)
Anemia	3 (2.1)
Other comorbidity (thyroid disease, asthma, gastritis, etc.)	26 (18.0)
History of previous surgeries	
Previous cesarean sections (twice or more)	24 (16.7)
Previous abdominal or pelvic surgeries	22 (15.3)
Current surgery indications	
Myomatosis/leiomyomas/fibromatosis	96 (66.7)
Pelvic adhesion syndrome	29 (20.1)
Endometriosis	25 (17.4)
Adenomyosis	24 (16.7)
Ovarian cyst/benign ovarian mass	19 (13.2)
Abnormal uterine bleeding	18 (12.5)
Gynecological cancer	7 (4.9)
Number of surgery indications	
1	85 (62.0)
2	39 (28.5)
≥ 3	13 (9.5)
Uterus weight, gr, median (min–max)	140 (44–1014)
Uterus weight ≥ 500gr	3 (2.1)
Type of surgical procedure	
Hysterectomy	104 (72.2)
Myomectomy	20 (13.9)
Oophorectomy	8 (5.6)
Other	12 (8.3)
Number of risk factors for surgical complications	
0	8 (5.6)
1	61 (42.4)
2	52 (36.1)
≥ 3	23 (15.9)

Table 2 Robot-assisted surgery attributes in complex and non-complex patients

	Total $n=144$	Non-complex patients $n=8$	1 risk factor $n=61$	2 risk factors $n=52$	3 risk factors $n=23$	*p*
Installation time, minutes. Median (min–max)	2 (1–17)	2 (1–5)	2 (1–8)	2 (1–10)	2 (1–17)	0.7127
Total surgery time, minutes. Median (min–max)	91 (41–250)	93.5 (47–143)	90 (41–239)	88.5 (40–240)	101 (45–250)	0.4946
Estimated intraoperative blood loss (ml), median (min–max)	25 (5–120)	25 (20–30)	25 (5–120)	20 (5–70)	20 (10–80)	0.5699
Hospital length of stay (days), mean (SD)[1]	1.78 (0.45)	1.62 (0.52)	1.72 (0.45)	1.87 (0.16)	1.83 (0. 24)	0.5059
Median (min–max)	2 (1–3)	2 (1–2)	2 (1–2)	2 (1–3)	2 (1–3)	

[1]*SD* Standard deviation. There were no intraoperative complications. One postoperative complication was reported. It was an open wound in the left port after 2 weeks

Table 3 Robotic surgery characteristics for different types of complex patients

Characteristics	Age ≥ 65 years $n=8$	Extreme obesity ≥ 40 kg/m^2 $n=9$	History of ≥ 2 cesarean sections $n=24$	Pelvic adhesion syndrome $n=29$	Gynecological cancer $n=7$	Hysterectomy $n=104$	Myomectomy $n=20$
Installation time, minutes Median (min–max)	2 (1–4)	2 (1–4)	2 (1–10)	2 (1–6)	3 (2–4)	3 (1–17)	2 (1–9)
Total surgery time, minutes. Median (min–max)	84 (55–246)	127 (60–250)	100.5 (45–172)	82 (40–240)	165 (64–250)	87 (41–250)	106 (54–214)
Estimated intraoperative blood loss (ml), median (min–max)	30 (15–50)	25 (5–80)	20 (10–70)	25 (5–70)	20 (15–70)	20.5 (5–120)	25 (15–50)
Hospital length of stay (days), mean (SD)[1] Median (min–max)	1.87 (0.64) 2 (1–3)	1.78 (0.44) 2 (1–2)	1.75 (0.44) 2 (1–2)	1.72 (0.45) 2 (1–2)	2.14 (0.69) 2 (1–3)	1.82 (0.43) 2 (1–3)	1.75 (0.44) 2 (1–2)

to the daVinci platform [28]. This cost advantage could be important for making HUGO RAS more accessible in low- and middle-income countries.

Study limitations

This study was a secondary analysis of health record data, which could be subject to sub-registry in patient pre- and postoperative health information. Despite this limitation, the large number of registered risk factors in this analysis suggests that the data obtained are reliable.

Further studies of RAS performance should include the cost-effectiveness analysis to ascertain the efficient use of hospital resources and the recovery time, which is the time required for patients to recover post-surgery and resume normal activities.

Conclusion

The Hugo™ RAS system for gynecological surgery was safe in patients with and without risk factors for surgery complications. These findings enhance our understanding of the use, safety, and health outcomes of RAS for gynecological procedures in the private healthcare sector of an upper-middle-income country. The results could be a reference for adopting this technology and developing best practices in the LAC region.

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Author contributions All authors contributed to the study conception and design. Miguel Ángel Cáceres Yap, Carlos Enrique Vargas Castillo, Martin Martino, Aneth Bonilla Cruz and Genova Itzel Hospina Espinosa prepared and obtained the ethical approval of the study protocol, participated in data acquisition, results interpretation and critically reviewed the manuscript for significant intellectual content. Salomón Zebedes, Marlene Mireya De Gracia Del Cid and José Luis Oviedo participated in data acquisition, results interpretation and critically reviewed the manuscript for significant intellectual content. Svetlana V. Doubova and Ricardo Pérez Cuevas analyzed data, prepared the first and the final draft of the paper. All authors read and approved the final manuscript. Acknowledgements: The authors would like to thank Celine Aybet Vergara Araúz and María Gabriela Rivera Cortes, fifth-year students in Medicine and Surgery at the Universidad Latina in Panamá.

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Data availability The deidentified data will be available upon reasonable request from the Dr. Svetlana V. Doubova, email: svetlana.doubova@gmail.com.

Declarations

Conflict of interests Dr Miguel Cáceres is proctor of HUGO RAS in Medtronic PLC and he is also this study grant-recipient. Dr. Ricardo Perez Cuevas received consultant honoraria from Medtronic PLC. The rest of the authors have no relevant financial or non-financial interests to disclose. All authors declare their complete independence from Medtronic PLC during the entire research process and are solely responsible for the methods, results, concepts, and conclusions in this manuscript.

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. The study protocol obtained Institutional Review Board approval of the Pacifica Salud Hospital (N#2586).

Consent to participate The manuscript presents the results of the secondary data retrospective analysis of patients who underwent gynecological surgery with HugoTM RAS System (Medtronic), according

to the institutional review bord the inclusion in the analysis of the deidentified patients' data did not require their consent. However, all patients who underwent surgery with HugoTM RAS System gave written informed consent for robotic surgery and were personally informed by the operating surgeon about the surgical procedure and its possible complications.

Consent to publish According to the institutional review bord the inclusion in the analysis of the deidentified patients' data did not require their consent to publish.

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