UTILIZATION OF ROBOTIC TECHNOLOGY IN HOSPITAL AMBULATORY SURGERY SETTINGS

Recommended Citation: Fingar KR, Stocks C, Gibson TB, McDermott KW, Pickens G, Utter GH, Karaca Z. Utilization of Robotic Technology in Hospital Ambulatory Surgery Settings. ONLINE. October 20, 2021. U.S. Agency for Healthcare Research and Quality. Available: www.hcup-us.ahrq.gov/reports.jsp.

The authors gratefully acknowledge the contribution of Richele Benevent of IBM Watson Health, as well as the 26 HCUP Partner organizations that contributed HCUP data used in this study: the Connecticut Hospital Association, the Georgia Hospital Association, the Hawaii Health Information Corporation, the Iowa Hospital Association, the Kansas Hospital Association, the Kentucky Cabinet for Health and Family Services, the Louisiana Department of Health, the Maryland Health Services Cost Review Commission, the Michigan Health & Hospital Association, the Minnesota Hospital Association, the Missouri Hospital Industry Data Institute, the Nebraska Hospital Association, the Nevada Department of Health and Human Services, the New Jersey Department of Health, the New York State Department of Health, the North Carolina Department of Health and Human Services, North Dakota (data provided by the Minnesota Hospital Association), the Ohio Hospital Association, the Oregon Association of Hospitals and Health Systems, the Pennsylvania Health Care Cost Containment Council, the South Carolina Revenue and Fiscal Affairs Office, the South Dakota Association of Healthcare Organizations, the Tennessee Hospital Association, the Texas Department of State Health Services, the Vermont Association of Hospitals and Health Systems, and the Wisconsin Department of Health Services.

ABSTRACT

Background

Some surgeons use robotic assistance to achieve dexterity and visualization that would be impossible through other approaches. Although use of robotic-assisted surgery has increased in the United States, the degree of use in ambulatory surgery settings is unknown.

Objective

To assess how the proportion of outpatient procedures with robotic assistance differs across procedure and facility types, and patient populations.

Study Design

In this cross-sectional study, we analyzed ambulatory surgery visits involving 12 procedures using data on hospital-owned facilities in 26 states from the 2016 Healthcare Cost and Utilization Project State Ambulatory Surgery and Services Databases. We compared robotic procedures with nonrobotic laparoscopic and nonlaparoscopic procedures.

Measures

We examined how the proportion of procedures performed robotically differed by expected payer, residence location, community-level income, census region, hospital ownership, and teaching status.

Results

The proportion of ambulatory procedures with robotic assistance was highest for pyeloplasty (15.1% of 1,903 procedures), myomectomy (14.7% of 14,069), and hysterectomy (10.1% of 301,251). The proportion of visits with robotic assistance was higher for patients with private insurance (4.1%) than for those with other types of insurance (1.9-2.5%; P<.001), higher in private for-profit hospitals (6.2%) compared with nonprofit (3.0%) and public (1.1%) hospitals (P<.001), and higher in nonteaching versus teaching hospitals (4.3% vs. 1.7%; P<.001).

Conclusions

Robotic-assisted surgery remains relatively uncommon in ambulatory surgery settings. Patients with private insurance and those at for-profit, nonteaching hospitals are most likely to undergo robotic-assisted procedures. This study provides baseline data on the extent to which ambulatory procedures involve robotic assistance.

INTRODUCTION

Robotic-assisted surgery is the use of small surgical tools manipulated by a robotic arm, which a surgeon controls with a computer.[1] Since 1985 when robotic-assisted surgery first was used in neurosurgical biopsy, robotic techniques have become increasingly common.[2,3] In 2017, more than 600,000 robotic-assisted operations occurred in the United States, making the nation the largest market for robotic surgery.[4] Robotic techniques are particularly useful in certain subspecialties, including gynecology, urology, and general surgery, that often involve procedures in the deep pelvis where robotic technology can increase dexterity (e.g., through 360-degree motion) and visualization (e.g., through three-dimensional images) within confined spaces.[5]

In recent decades, the volume of and revenue associated with outpatient operations have steadily increased.[6-10] This growth is driven in part by improved technology in ambulatory surgical settings. An increase in the use of robotic technology in outpatient settings has been documented.[11-15] However, most studies of the safety and efficacy of robotic surgery have been conducted in inpatient settings and have yielded mixed results. The limited research in outpatient settings has focused on specific robotic procedures, such as hysterectomy or cholecystectomy, or has been conducted in a select number of surgical centers.[11,12,16,17]

Benefits of robotic surgery are reported to include faster recovery; less postoperative pain and analgesic use; decreased risk of blood loss, infection, and other complications; and enhanced cosmetic results.[18,19] However, other research has suggested that the benefits for patients are minimal and may not warrant the costly initial capital investment for equipment; ongoing costs of maintenance, training, and staffing; and longer operating times.[20-22] Furthermore, compared with other surgical approaches, robotic-assisted hysterectomy may be associated with shorter survival times among patients with cervical cancer, as well as higher postoperative revisit rates among women with nonmalignant conditions.[23-26]

There is a dearth of information not only on the efficacy of robotic surgery in outpatient settings but also on how often various outpatient procedures are performed robotically, types of facilities that use this technology, characteristics of patients who undergo these procedures, and variation in spending by surgical approach. In this study, we describe the degree to which robotic technology is used throughout ambulatory surgery settings across hospitals in the United States and assess how the proportion of procedures performed robotically differs across procedure and facility types, and across patient populations. In a secondary analysis, we explore differences in spending between robotic-assisted and nonrobotic laparoscopic procedures.

METHODS

Data Source

For our primary analysis, we used the 2016 Healthcare Cost and Utilization Project (HCUP) State Ambulatory Surgery and Services Databases (SASD)[27] for 26 states (see Acknowledgements for a list of states). We included hospital-owned outpatient facilities (as opposed to free-standing facilities, for which data are not contributed by every state) that could be linked to the American Hospital Association Annual Survey, the source of data for facility characteristics. To calculate annual volume, we selected facilities that contributed data in all 4 quarters of 2016 and did not have irregularities in quarterly volume. Level II Healthcare Common Procedure Coding System (HCPCS) codes are used to identify robotic surgery, but not all facilities consistently report Level II HCPCS codes. Therefore, we included only facilities

at which at least 90% of outpatient discharges had a Level II HCPCS code documented in any procedure listed on the record.

Charges are documented in the SASD, but those charges generally are higher relative to the actual cost of care and the amount that hospitals charge for similar services varies. Currently, unlike for inpatient data, there are no generally accepted cost estimation methods for ambulatory surgery data.[28] Therefore, we supplemented our analysis of charges in the SASD with payments using data from the IBM® MarketScan® Commercial Database for patients with employer-sponsored health insurance in the same 26 states. For consistency with the MarketScan commercial data, we compared these results with a similar analysis of charges in the SASD, which was restricted to patients with private insurance. To better interpret the charge and payment results across these two different data sources, we verified the regional distribution of ambulatory surgery visits included in this study from the SASD and the MarketScan Commercial Database (see Appendix Table A.1). The distributions generally were similar across the two data sources.

Definition of Robotic-Assisted Procedures

We identified *robotic-assisted procedures* as those with a Level II HCPCS code of S2900, G0339, or G0340 (see Appendix Table A.2). We focused on procedures for which 1% or more were performed robotically. Those procedures included cervical excision and trachelectomy; cholecystectomy; colpopexy and other procedures to treat pelvic organ prolapse; excision of lesions of the ovary, pelvic viscera, or peritoneal surface; hysterectomy; incisional and other ventral hernia repair; inguinal and femoral hernia repair; myomectomy; oophorectomy; paraesophageal hernia repair and esophagogastric fundoplasty; prostatectomy; and pyeloplasty. More than 1% of outpatient knee arthroplasty procedures were performed robotically, but we excluded this procedure because it involves different equipment and functions than the robotic techniques applied to the intra-abdominal/pelvic procedures listed above.

For each procedure, we categorized the approach as robotic, nonrobotic laparoscopic, or nonrobotic nonlaparoscopic (i.e., all other approaches, which generally include open approaches, either through an incision or via a natural opening, such as the vagina). See Appendix Table A.3 for procedure codes and definitions.

Patient and Hospital Characteristics

We examined the proportion of procedures performed robotically by patient characteristics (first-listed expected payer, urban/rural location of patient residence, and quartiles of median household income in the patient's ZIP Code of residence) and by hospital characteristics (region, ownership, and teaching status), based on definitions found in HCUP documentation.[29]

Spending

Using data from the SASD, we examined billed charges per procedure, which generally include facility charges but not professional fees and noncovered charges.[29] For consistency with the data from the MarketScan Commercial Database, we limited our analysis of charges in the SASD to patients with an expected payer of private insurance. For consistency with the types of charges reported in the SASD, we limited our analysis of payments (allowed charges) among patients with private, employer-sponsored insurance coverage in the MarketScan Commercial Database to facility payments. Payments include those made by the insurer and out-of-pocket costs to the patient.

Analysis

We examined differences in the proportion of procedures performed robotically across patient and hospital characteristics. We also used Poisson regression models to examine the difference in charges and payments associated with robotic-assisted surgery versus the nonrobotic laparoscopic approach. To isolate spending associated with robotic technology, above what would be observed for a traditional laparoscopic approach, we focused on these two approaches and not on open approaches.

We present results from unadjusted models, as well as models that included age as a covariate and fixed effects for the hospital identifier in the SASD. The latter control for hospital-level differences in charges; thus, the charge difference estimated by the adjusted models reflects within-hospital comparisons across surgical approaches. Similarly, the MarketScan Commercial Database models included a fixed effect for the employer health insurance plan, which controls for differences in payments that may result from variation in negotiations between insurers and hospitals. We included age and not a broader set of patient clinical characteristics (e.g., uterine size) because we did not want to overcontrol for conditions (e.g., cancer) that might indicate need for a particular surgical approach but also complicate procedures, leading to higher charges.

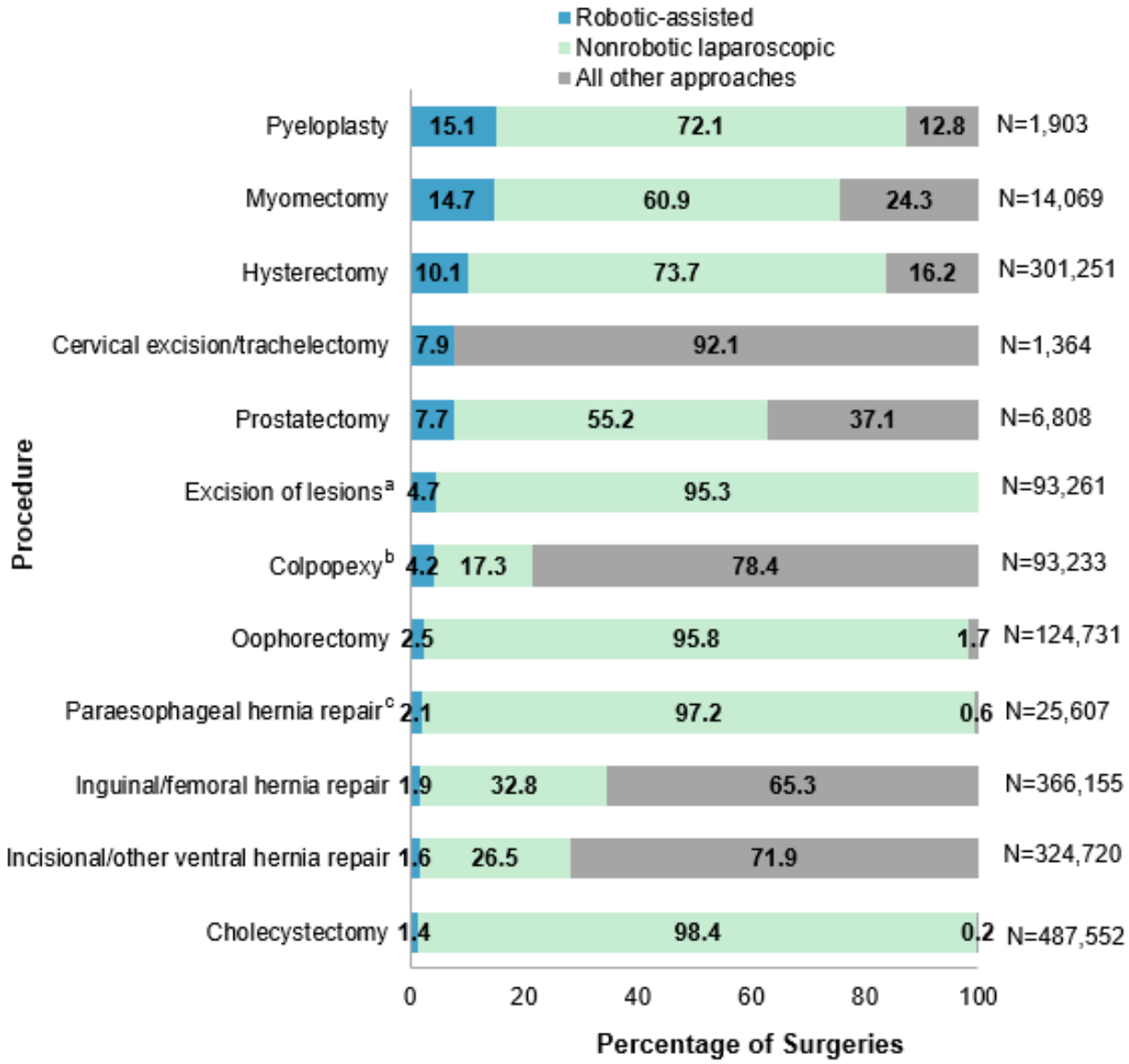
RESULTS

Ambulatory Procedures Performed Robotically

We identified 1.8 million ambulatory procedures of interest and 65,000 robotic-assisted operations across the 12 procedure categories (Figure 1). The proportion of ambulatory procedures performed robotically was greatest for pyeloplasty, myomectomy, and hysterectomy—constituting 15.1% of 1,903, 14.7% of 14,069, and 10.1% of 301,251 procedures, respectively. For these three procedures, 60-74% involved nonrobotic laparoscopic techniques.

For cervical excision/trachelectomy and prostatectomy, nearly 8% of procedures were robotic assisted. Less than 5% of the remaining procedures were performed robotically. The highest volume procedures were hernia repair and cholecystectomy. However, the proportion of robotic-assisted procedures was lowest for cholecystectomy (1.4%) and was 1.8% for hernia repair overall (1.6% for incisional/other ventral hernia repair; 1.9% for inguinal/femoral hernia repair; 2.1% for paraesophageal hernia repair and esophagogastric fundoplasty). Together hernia repair (N=12,811 robotic procedures) and cholecystectomy (N=6,778 robotic procedures) constituted nearly 20,000 ambulatory robotic procedures.

Figure 1. Surgical Approach for 12 Select Procedures Performed in Hospital-Owned Ambulatory Surgery Centers in 26 States, 2016



Excision of lesions indicates Excision of lesions of ovary, pelvic viscera, or peritoneal surface; Colpopexy, Colpopexy and other procedures to treat pelvic organ prolapse; Paraesophageal hernia repair, Paraesophageal hernia repair and esophagogastric fundoplasty.

Robotic Surgery by Patient Characteristics

For the 12 ambulatory procedures combined, the proportion with robotic assistance was lower among Medicare (1.9%) and Medicaid (2.5%) patients and among patients with an expected payer of self-pay/no charge (1.9%), compared with patients with private insurance (4.1%) (*P*<.001) (Table 1).

For the 12 procedures combined, the proportion with robotic assistance was lower among patients living in micropolitan (1.8%) and rural areas (1.8%), compared with those living in metropolitan areas (3.7%) (*P*<.001), and also lower among patients from the lowest income communities (income quartile 1; 2.6%), compared with those from the highest income communities (quartile 4; 4.1%; p<0.001). Generally, similar findings were observed for each of the 12 procedures.

Table 1. Robotic-Assisted Surgery for Select Procedures Performed in Hospital-Owned Ambulatory Surgery Centers in 26 States by Patient Characteristic, 2016

Procedure	Percentage of Procedures With Robotic Assistance									
	Primary Expected Payer				Location			Community Income		
	Medicare	Medicaid	Private	Self-Pay/No Charge	Metropolitan	Micropolitan	Rural	Quartile 1 (Lowest)	Quartiles 2-3	Quartile 4 (Highest)
Total 12 procedures	1.9§	2.5§	4.1	1.9§	3.7	1.8§	1.8§	2.6§	3.3§	4.1
Pyeloplasty	11.9§	11.3§	17.7	—ǀ	16.1	11.8	9.9§	12.9§	13.4§	20.8
Procedures of female organs, total	4.4§	4.7§	7.8	5.2§	7.5	3.7§	4.0§	5.4§	6.6§	8.6
Myomectomy	13.5	10.2§	15.8	7.4§	15.3	5.5§	5.1§	12.0§	14.4§	17.3
Hysterectomy	7.1§	8.2§	11.1	8.4§	11.1	5.8§	6.2§	8.3§	9.7§	12.9
Cervical excision/ trachelectomy	—ǀ	8.6	8.6	—ǀ	8.6	—ǀ	—ᵛ	3.9§	9.2	8.5
Colpopexy*	2.3§	4.0§	5.6	3.0§	4.8	2.2§	2.4§	3.2§	4.1§	5.7
Oophorectomy	2.8	1.1§	3.0	1.2§	2.8	1.0§	1.0§	1.7§	2.5§	3.3
Excision of lesions†	6.9§	2.3§	5.3	2.9§	5.2	2.1§	1.9§	3.4§	4.4§	6.4
Prostatectomy	2.9§	—ǀ	10.9	—ǀ	8.0	7.3	4.6§	6.4	8.3	7.8
Hernia repair, total	1.3§	1.3§	2.1	1.1§	1.9	1.0§	0.9§	1.5§	1.8	1.8
Paraesophageal‡	1.8	3.6§	2.1	—ǀ	2.3	1.5§	1.8	1.7§	2.2	2.4
Inguinal/femoral	1.4§	1.2§	2.4	1.3§	2.1	0.9§	1.0§	1.7§	2.0	1.9
Incisional/other ventral	1.3§	1.3§	1.9	0.9§	1.8	1.1§	0.8§	1.4§	1.7	1.7
Cholecystectomy	0.9§	1.5	1.6	0.6§	1.6	0.9§	0.9§	1.1§	1.5	1.5

* Colpopexy and other procedures to treat pelvic organ prolapse.

† Excision of lesions of ovary, pelvic viscera, or peritoneal surface.

‡ Paraesophageal hernia repair and esophagogastric fundoplasty.

§ Chi-square test for difference in the percentage of robotic procedures = *P*<.05 (reference groups were patients with private insurance, from metropolitan areas, and with community income in quartile 4).

ǀ Not shown; number of events ≤10.

Robotic Surgery by Hospital Characteristics

For the 12 ambulatory procedures combined, the proportion with robotic assistance was higher among hospitals in the Northeast (4.3%) than among hospitals in the South (3.4%), West (2.6%), and Midwest (2.5%) (*P*<.001); higher for private for-profit hospitals (6.2%) than for private nonprofit (3.0%) and public hospitals (1.1%) (*P*<.001); and higher for nonteaching (4.3%) than for teaching hospitals (1.7%) (*P*<.001) (Table 2).

These findings were observed for most of the 12 procedures, including hysterectomy for which the proportion performed robotically reached 15.4% in the Northeast, 15.7% in private for-profit hospitals, and 12.5% in teaching hospitals. However, for several other procedures, robotic assistance was slightly more common in the West than in the Northeast, including total hernia repair (2.4% West, 2.2% Northeast; *P*=.01) and cholecystectomy (2.5% West, 1.9% Northeast; *P*<.001).

Table 2. Robotic-Assisted Surgery for Select Procedures Performed in Hospital-Owned Ambulatory Surgery Centers in 26 States by Hospital Characteristic, 2016

Procedure	Percentage of Procedures With Robotic Assistance								
	Census Region				Ownership			Teaching	
	Northeast	Midwest	South	West	Private, for Profit	Private, Nonprofit	Public	Teaching	Nonteaching
Total 12 procedures	4.3	2.5§	3.4§	2.6§	6.2	3.0§	1.1§	1.7	4.3§
Pyeloplasty	19.5	10.6§	17.2	—‖	15.7	16.1	7.6§	16.0	15.0
Procedures of female organs, total	9.5	5.3§	6.9§	3.0§	11.1	6.5§	1.6§	3.3	8.4§
Myomectomy	24.5	6.1§	12.1§	4.1§	15.6	15.5	2.5§	4.4	17.2§
Hysterectomy	15.4	8.4§	9.8§	4.2§	15.7	9.8§	2.7§	5.2	12.5§
Cervical excision/ trachelectomy	12.1	3.6§	9.0	—‖	18.3	7.7§	—‖	5.9	8.8
Colpopexy*	6.4	2.6§	4.6§	3.3§	8.6	3.9§	0.8§	2.3	5.1§
Oophorectomy	3.3	1.1§	3.3	1.1§	5.2	2.4§	0.3§	1.2	3.2§
Excision of lesions†	6.4	2.5§	5.6§	2.1§	8.8	4.4§	0.7§	2.5	5.8§
Prostatectomy	5.1	3.1§	12.2§	—‖	4.5	8.9§	2.6	4.8	8.9§
Hernia repair, total	2.2	1.3§	1.7§	2.4§	3.9	1.5§	0.9§	1.2	2.0§
Paraesophageal‡	3.4	1.6§	1.5§	9.5§	4.6	1.6§	1.4§	1.0	3.0§
Inguinal/femoral	2.3	1.4§	1.9§	2.6§	4.5	1.6§	1.0§	1.4	2.2§
Incisional/other ventral	2.1	1.1§	1.7§	1.9	3.5	1.4§	0.9§	1.2	1.9§
Cholecystectomy	1.9	1.0§	1.3§	2.5§	3.4	1.1§	0.9§	0.8	1.9§

* Colpopexy and other procedures to treat pelvic organ prolapse.

† Excision of lesions of ovary, pelvic viscera, or peritoneal surface.

‡ Paraesophageal hernia repair and esophagogastric fundoplasty.

§ Chi-square test for difference in the percentage of robotic procedures = *P*<.05 (reference groups were patients with private insurance, from metropolitan areas, and with community income in quartile 4).

‖ Not shown; number of events ≤10.

Charges and Payments for Robotic Surgery for Patients With Private Insurance

In unadjusted models for the 12 ambulatory procedures combined, among patients with an expected payer of private insurance, charges for procedures involving robotic surgery were 61.8% (95% confidence interval [CI]: 60.7%, 62.9%) higher than those for nonrobotic laparoscopic procedures (Table 3). Adjusting for age and hospital fixed effects attenuated the association between robotic versus nonrobotic laparoscopic surgery and charges to 17.9% (95% CI: 12.1%, 24.0%). In the models adjusted for age and hospital fixed effects, charges generally were higher for robotic than for nonrobotic laparoscopic procedures, ranging from 10.1% (95% CI: 6.2%, 14.2%) higher for hysterectomy to 45.9% (95% CI: 34.0%, 58.8%) higher for excision of lesions of the ovary, pelvic viscera, or peritoneal surface. We did not find that robotic surgery was associated with higher charges for pyeloplasty, colpopexy, prostatectomy, and paraesophageal hernia repair (*P*>.05).

Payments, as measured in the MarketScan Commercial Database for individuals with private employer-sponsored health coverage, were 29% lower than charges as measured in the SASD. For the 12 procedures combined, the average payment for robotic surgery was $11,500, whereas the average charge was $40,000.

In the adjusted models of payments in the MarketScan Commercial Database, we found no association between robotic versus nonrobotic laparoscopic surgery and payments for the 12 procedures combined (1.033; 95% CI: 0.992, 1.075). For some procedures, payments were higher for robotic-assisted procedures than for nonrobotic laparoscopic procedures, ranging from 14.3% (95% CI: 5.8%, 24.2%) higher for robotic inguinal/femoral hernia repair to 65.6% (95% CI: 18.2%, 132.2%) higher for robotic paraesophageal hernia repair. We did not find an association between robotic-assisted surgery and payments for colpopexy, prostatectomy, or incisional/other ventral hernia repair. Robotic versus nonrobotic laparoscopic surgery was associated with lower payments for pyeloplasty and hysterectomy.

Table 3. Association of Robotic-Assisted Surgery With Charges and Payments Among Patients With Private Insurance*

Procedure	Charges or Payments, $ (Mean)			Robotic Versus Nonrobotic Laparoscopic, e^{β} (95% Confidence Interval)	
	Robotic-Assisted	Nonrobotic Laparoscopic	All Other Approaches	Unadjusted Model	Adjusted Model
Charges, State Ambulatory Surgery and Services Database					
Total 12 procedures	40,000	25,000[‖]	17,100[‖]	1.618 (1.607-1.629)	1.179 (1.121-1.240)
Pyeloplasty	52,400	42,300[‖]	31,200[‖]	1.197 (1.101-1.302)	0.981 (0.900-1.071)
Procedures of female organs, total	43,100	29,400[‖]	24,000[‖]	1.415 (1.403-1.427)	1.127 (1.087-1.169)
Myomectomy	62,200	35,300[‖]	24,200[‖]	1.800 (1.731-1.872)	1.216 (1.061-1.394)
Hysterectomy	41,900	34,400[‖]	24,200[‖]	1.248 (1.236-1.259)	1.101 (1.062-1.142)
Cervical excision/ trachelectomy	48,400	—[**]	26,300[‖]	—[**]	—[**]
Colpopexy[†]	50,700	46,000[‖]	27,200[‖]	1.154 (1.124-1.184)	1.041 (0.986-1.099)
Oophorectomy	42,600	22,600[‖]	25,200[‖]	1.878 (1.820-1.938)	1.445 (1.301-1.604)

Procedure	Charges or Payments, $ (Mean)			Robotic Versus Nonrobotic Laparoscopic, e^{β} (95% Confidence Interval)	
	Robotic-Assisted	Nonrobotic Laparoscopic	All Other Approaches	Unadjusted Model	Adjusted Model
Excision of lesions‡	46,200	23,300|	—¶	1.974 (1.924-2.025)	1.459 (1.340-1.588)
Prostatectomy	58,900	44,900|	33,000|	1.446 (1.319-1.585)	1.051 (0.990-1.117)
Hernia repair, total	34,200	25,600|	15,600|	1.408 (1.388-1.428)	1.192 (1.102, 1.290)
Paraesophageal§	56,100	36,200|	40,500|	1.526 (1.427-1.631)	0.959 (0.762-1.206)
Inguinal/femoral	30,800	22,400|	15,200|	1.506 (1.481-1.532)	1.218 (1.138-1.304)
Incisional/other ventral	36,700	26,800|	16,400|	1.390 (1.360-1.420)	1.222 (1.141-1.308)
Cholecystectomy	27,600	19,900|	25,500|	1.440 (1.417-1.464)	1.186 (1.097-1.283)
Payments, MarketScan Commercial Database					
Total 12 procedures	11,500	9,800|	6,700|	1.613 (1.602-1.624)	1.033 (0.992-1.075)
Pyeloplasty	9,700	17,600|	15,200|	0.555 (0.389-0.794)	0.575 (0.411-0.806)
Procedures of female organs, total	11,800	11,400|	9,100|	1.038 (1.007-1.071)	0.975 (0.932-1.019)
Myomectomy	17,200	13,000|	8,000|	1.320 (1.133-1.538)	1.380 (1.135-1.676)
Hysterectomy	11,600	12,400|	9,600|	0.934 (0.904-0.966)	0.938 (0.898-0.980)
Cervical excision/ trachelectomy	—¶	—**	10,900	—**	—**
Colpopexy†	14,000	15,600|	10,900|	0.896 (0.809-0.992)	0.945 (0.791-1.128)
Oophorectomy	11,000	9,100|	8,500|	1.201 (1.084-1.332)	1.187 (1.055-1.335)
Excision of lesions‡	13,900	9,600|	—¶	1.451 (1.311-1.605)	1.436 (1.262-1.634)
Prostatectomy	12,100	15,800	12,000	0.767 (0.517-1.136)	0.847 (0.463-1.549)
Hernia repair, total	11,500	10,400|	6,200|	1.101 (1.017-1.192)	1.160 (1.078-1.248)
Paraesophageal§	26,200	16,000|	—¶	1.637 (1.193-2.245)	1.656 (1.182-2.322)
Inguinal/femoral	9,600	8,800	5,800|	1.090 (0.994-1.195)	1.143 (1.052-1.242)
Incisional/other ventral	11,700	10,900	6,700|	1.070 (0.982-1.166)	1.060 (0.969-1.160)
Cholecystectomy	9,600	8,300|	6,200|	1.157 (1.077-1.244)	1.150 (1.058-1.249)

* The adjusted model includes age and fixed effects for hospital (State Ambulatory Surgery and Services Database) or employer plan (MarketScan Commercial Database).

† Colpopexy and other procedures to treat pelvic organ prolapse.

‡ Excision of lesions of ovary, pelvic viscera, or peritoneal surface.

§ Paraesophageal hernia repair and esophagogastric fundoplasty.

| T-test for difference in charges or payments between robotic and nonrobotic procedures = $P<0.05$.

¶ Not shown; number of events ≤10.

** By definition, cervical excision/trachelectomy is not performed using a nonrobotic laparoscopic approach and therefore was not included in the regression models.

DISCUSSION

In this study of hospital-owned outpatient facilities in 26 states, we captured 65,000 robotic ambulatory surgery visits for 12 procedures in which robotic techniques are commonly used. Our findings suggest that robotic-assisted surgery still accounts for a relatively small share of total ambulatory procedures. Among the procedures examined, the proportion of robotic-assisted surgery ranged from 1.4% for cholecystectomy (a very common ambulatory procedure) to 15.1% for pyeloplasty (a relatively uncommon ambulatory procedure). Thus, despite reports that robotic technology is becoming more common at outpatient facilities, for most ambulatory procedures, robotic technology rarely is used. However, robotic techniques may be concentrated at relatively few hospitals that have invested in technology and surgical training and that take referrals for cases indicating a robotic approach.[5] Our results suggest that hospitals with a higher proportion of ambulatory robotic procedures are likely to be nonteaching and for-profit hospitals in the Northeast.

Studies have documented disparities in access to robotic surgery.[11,30,31] After controlling for demographic and clinical factors, Price et al. (2017) found that race/ethnicity, Medicaid enrollment, and income were associated with lower odds of robotic hysterectomy.[30] We found that robotic hysterectomy and most of the other ambulatory robotic procedures were less likely to be performed among patients without private insurance, from nonmetropolitan areas, and with lower community-level incomes than among patients with private insurance, from metropolitan areas, and with higher community-level incomes.

Some studies have noted that the minimal benefits of robotic surgery for patients may not justify the expense.[18-20] Our analysis of hospital charges in the SASD aligned with payments from the MarketScan Commercial Database for privately insured patients can shed light on issues related to the financing of these kinds of procedures. There are two related points worth mentioning. First, for these 12 ambulatory procedures overall, payments for robotic-assisted procedures constituted 29% of charges for patients with private insurance. Thus, although hospitals may bill more for robotic surgery, negotiated payments between hospitals and private insurance plans are much lower, as are prices and reimbursement rates in general when compared with charges.[32] We supplemented our analysis of charges with payments because currently there is no accepted cost estimation methodology for ambulatory surgery data. However, the difference between payments and charges in our study is consistent with the ratio of costs to charges for total inpatient stays in the United States in 2016, which was 25%, down from 44% in 2000.[33]

Second, numerous studies have documented higher spending associated with robotic versus nonrobotic surgery.[34-41] In adjusted models, we found that charges were 18% higher for robotic than for nonrobotic laparoscopic procedures for the 12 procedures overall. However, payments were not higher after adjusting for differences across plan reimbursement structures. Thus, within plans, payments for robotic procedures were not statistically different from those for nonrobotic laparoscopic procedures.

These findings warrant more research to understand how costs associated with robotic surgery are distributed across patients, payers, and hospitals. Salient issues include whether there may be long-term effects of robotic surgery on health insurance premiums and out-of-pocket costs. A recent study found robotic surgery was associated with lower out-of-pocket costs for oncologic procedures relative to open surgery but did not examine nonrobotic laparoscopic approaches.[42] Additionally, future studies may explore reimbursement for robotic surgery, particularly for patients with Medicare, which does not reimburse claims based on the Level II HCPCS code S2900 for robotic surgery (the most common code for robotic surgery used in our data), but only

based on Current Procedural Terminology codes that differentiate laparoscopic from nonlaparoscopic procedures.[43] Future research also may focus on the extent to which reimbursement by private or public payers covers the cost of robotic-assisted surgery for hospitals and hospital responses to recoup costs. For instance, hospitals may shift costs across robotic and nonrobotic surgical visits.[39] Outpatient robotic surgery also may help offset the investment made for inpatient procedures.

Finally, robotic approaches may be favored for procedures involving the deep pelvis where improved visualization and the greater degrees of freedom of robotic instruments substantially facilitate the procedure. For other procedures, including cholecystectomy, inguinal hernia repair, and appendectomy, robotic visualization and instrumentation may be no more advantageous than that with standard laparoscopic techniques[21]; thus, benefits of a robotic approach may not outweigh additional costs. Although the proportion of robotic cholecystectomies and inguinal/femoral hernia repairs was relatively low (below 2%), second to hysterectomy, these two procedures constituted the second largest number of ambulatory robotic procedures and therefore should be monitored by researchers assessing the safety and efficacy of robotic surgery in ambulatory settings.

Our study has several limitations. Although we excluded hospitals with fewer than 90% of ambulatory surgery visits with a Level II HCPCS code, the HCPCS code for robotic surgery still may be underreported if it is not commonly used for billing.[43] To our knowledge, this study provides the most comprehensive summary of use of robotic technology for hospital-based ambulatory procedures in the United States. Although we included data from only 26 states, these states constituted 58% of the U.S. population in 2016.[44] However, the proportion of procedures performed robotically in these states may not be generalizable to other states. Finally, we did not examine clinical outcomes of ambulatory robotic-assisted surgery, and without validated estimation methods, we cannot comment on outpatient costs, nor was this the goal of the current study. We suspect that the spending differentials we report between robotic surgery and the nonrobotic laparoscopic approach could be biased downward because robotic-related Level II HCPCS codes may be underreported and because hospitals can shift costs from robotic to nonrobotic surgical visits. Because we did not include inpatient data, we were unable to monitor how often complications of ambulatory robotic surgery resulted in an inpatient stay or further surgical intervention in the inpatient setting.

CONCLUSION

Although the proportion of ambulatory robotic procedures was generally low, 1 in 10 outpatient hysterectomies were performed robotically. Hysterectomy is a common ambulatory procedure, and more than 30,000 outpatient robotic hysterectomies in 26 states were included in this study. Only 1.4% of cholecystectomies and 1.9% of inguinal/femoral hernia repairs were robotic assisted, yet, next to hysterectomy, these two procedures constituted the second highest number of ambulatory robotic operations (nearly 20,000). Given questions about the benefits of robotic-assisted surgery for certain procedures (e.g., cholecystectomy and inguinal hernia repair)[20] and emerging evidence documenting poorer outcomes for patients undergoing robotic-assisted hysterectomy for cervical cancer,[22-25] our study is an important step in describing some basic characteristics of outpatient robotic surgery and advancing research on this topic. Additional studies using longitudinal data may reveal whether the findings we observed are static or dynamic, and those comparing data from inpatient and outpatient settings may more fully describe the use of robotic technology.

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APPENDIX

Table A.1. Regional Distribution of Ambulatory Surgery Visits Included in This Study From the HCUP SASD Among Patients With Private Insurance and the MarketScan Commercial Database

Region	SASD		MarketScan Commercial Database	
	n	%	n	%
Northeast	259,072	28.7	19,880	17.0
Midwest	168,487	18.7	35,045	29.9
South	422,387	46.8	59,148	50.5
West	51,728	5.7	2,947	2.5

HCUP indicates Healthcare Cost and Utilization Study; SASD, State Ambulatory Surgery and Services Database.

Table A.2. Level II HCPCS Codes Defining Robotic Surgery

HCPCS Code	Description
S2900	Surgical techniques requiring use of robotic surgical system
G0339	Image-guided robotic linear accelerator-based stereotactic radiosurgery, complete course of therapy in one session or first session of fractionated treatment
G0340	Image-guided robotic linear accelerator-based stereotactic radiosurgery, delivery including collimator changes and custom plugging, fractionated treatment, all lesions, per session, second through fifth sessions, maximum five sessions per course of treatment

HCPCS indicates Healthcare Common Procedure Coding System.

Table A.3. CPT Codes Defining the 12 Procedures of Interest

CPT Code	Description	Laparoscopic or Nonlaparoscopic
	Cervical Excision and Trachelectomy	
57530	Trachelectomy (cervicectomy), amputation of cervix (separate procedure)	Nonlaparoscopic
57550	Excision of cervical stump, vaginal approach;	Nonlaparoscopic
57531	Radical trachelectomy, with bilateral total pelvic lymphadenectomy and para-aortic lymph node sampling biopsy, with or without removal of tube(s), with or without removal of ovary(s)	Nonlaparoscopic
57540	Excision of cervical stump, abdominal approach;	Nonlaparoscopic
57545	Excision of cervical stump, abdominal approach; with pelvic floor repair	Nonlaparoscopic
	Cholecystectomy	
47562	Laparoscopy, surgical; cholecystectomy	Laparoscopic
47563	Laparoscopy, surgical; cholecystectomy with cholangiography	Laparoscopic
47564	Laparoscopy, surgical; cholecystectomy with exploration of common duct	Laparoscopic
47600	Cholecystectomy	Nonlaparoscopic
47605	Cholecystectomy; with cholangiography	Nonlaparoscopic
47610	Cholecystectomy with exploration of common duct;	Nonlaparoscopic

CPT Code	Description	Laparoscopic or Nonlaparoscopic
47612	Cholecystectomy with exploration of common duct; with choledochoenterostomy	Nonlaparoscopic
47620	Cholecystectomy with exploration of common duct; with transduodenal sphincterotomy or sphincteroplasty, with or without cholangiography	Nonlaparoscopic
	Colpopexy and Other Procedures to Treat Pelvic Organ Prolapse	
57425	Laparoscopy, surgical, colpopexy (suspension of vaginal apex)	Laparoscopic
57282	Colpopexy, vaginal; extra-peritoneal approach (sacrospinous, iliococcygeus)	Nonlaparoscopic
57283	Colpopexy, vaginal; intra-peritoneal approach (uterosacral, levator myorrhaphy)	Nonlaparoscopic
57280	Colpopexy, abdominal approach	Nonlaparoscopic
57260	Combined anteroposterior colporrhaphy, including cystourethroscopy, when performed. Typically performed by combined vaginal perineal approach	Nonlaparoscopic
57240	Anterior colporrhaphy, repair of cystocele with or without repair of urethrocele, including cystourethroscopy, when performed. Typically performed via vaginal approach	Nonlaparoscopic
57250	Posterior colporrhaphy, repair of rectocele with or without perineorrhaphy. Typically performed via perineal approach	Nonlaparoscopic
57265	Combined anteroposterior colporrhaphy, including cystourethroscopy, when performed; with enterocele repair. Typically performed by combined vaginal perineal approach	Nonlaparoscopic
57120	Colpocleisis (Le Fort type). Transvaginal approach	Nonlaparoscopic
45560	Repair of rectocele (separate procedure). Typically performed via vaginal approach	Nonlaparoscopic
57268	Repair of enterocele, vaginal approach (separate procedure)	Nonlaparoscopic
57285	Paravaginal defect repair (including repair of cystocele, if performed); vaginal approach	Nonlaparoscopic
57423	Paravaginal defect repair (including repair of cystocele, if performed), laparoscopic approach	Laparoscopic
57230	Plastic repair of urethrocele. Typically performed via transurethral approach	Nonlaparoscopic
57289	Pereyra procedure, including anterior colporrhaphy. Pereyra procedure performed for stress urinary incontinence. The colporrhaphy with this procedure is typically performed vaginally.	Nonlaparoscopic
57270	Repair of enterocele, abdominal approach (separate procedure)	Nonlaparoscopic
57284	Paravaginal defect repair (including repair of cystocele, if performed); open abdominal approach	Nonlaparoscopic
57555	Excision of cervical stump, vaginal approach; with anterior and/or posterior repair	Nonlaparoscopic
57556	Excision of cervical stump, vaginal approach; with repair of enterocele	Nonlaparoscopic
58400	Uterine suspension, with or without shortening of round ligaments, with or without shortening of sacrouterine ligaments; (separate procedure)	Nonlaparoscopic

CPT Code	Description	Laparoscopic or Nonlaparoscopic
58410	Uterine suspension, with or without shortening of round ligaments, with or without shortening of sacrouterine ligaments; with presacral sympathectomy	Nonlaparoscopic
	Excision of Lesions of the Ovary, Pelvic Viscera, or Peritoneal Surface	
58662	Laparoscopy, surgical; with fulguration or excision of lesions of the ovary, pelvic viscera, or peritoneal surface by any method	Laparoscopic
	Hysterectomy	
58571	Laparoscopy, surgical, with total hysterectomy, for uterus 250 g or less; with removal of tube(s) and/or ovary(s)	Laparoscopic
58573	Laparoscopy, surgical, with total hysterectomy, for uterus greater than 250 g; with removal of tube(s) and/or ovary(s)	Laparoscopic
58570	Laparoscopy, surgical, with total hysterectomy, for uterus 250 g or less	Laparoscopic
58572	Laparoscopy, surgical, with total hysterectomy, for uterus greater than 250 g;	Laparoscopic
58552	Laparoscopy, surgical, with vaginal hysterectomy, for uterus 250 g or less; with removal of tube(s) and/or ovary(s)	Laparoscopic
58550	Laparoscopy, surgical, with vaginal hysterectomy, for uterus 250 g or less	Laparoscopic
58554	Laparoscopy, surgical, with vaginal hysterectomy, for uterus greater than 250 g; with removal of tube(s) and/or ovary(s)	Laparoscopic
58553	Laparoscopy, surgical, with vaginal hysterectomy, for uterus greater than 250 g	Laparoscopic
58542	Laparoscopy, surgical, supracervical hysterectomy, for uterus 250 g or less; with removal of tube(s) and/or ovary(s)	Laparoscopic
58544	Laparoscopy, surgical, supracervical hysterectomy, for uterus greater than 250 g; with removal of tube(s) and/or ovary(s)	Laparoscopic
58541	Laparoscopy, surgical, supracervical hysterectomy, for uterus 250 g or less;	Laparoscopic
58543	Laparoscopy, surgical, supracervical hysterectomy, for uterus greater than 250 g;	Laparoscopic
58548	Laparoscopy, surgical, with radical hysterectomy, with bilateral total pelvic lymphadenectomy and para-aortic lymph node sampling (biopsy), with removal of tube(s) and ovary(s), if performed	Laparoscopic
58260	Vaginal hysterectomy, for uterus 250 g or less	Nonlaparoscopic
58262	Vaginal hysterectomy, for uterus 250 g or less; with removal of tube(s), and/or ovary(s)	Nonlaparoscopic
58263	Vaginal hysterectomy, for uterus 250 g or less; with removal of tube(s), and/or ovary(s), with repair of enterocele	Nonlaparoscopic
58270	Vaginal hysterectomy, for uterus 250 g or less; with repair of enterocele	Nonlaparoscopic
58291	Vaginal hysterectomy, for uterus greater than 250 g; with removal of tube(s) and/or ovary(s)	Nonlaparoscopic
58290	Vaginal hysterectomy, for uterus greater than 250 g	Nonlaparoscopic

CPT Code	Description	Laparoscopic or Nonlaparoscopic
58267	Vaginal hysterectomy, for uterus 250 g or less; with colpo-urethrocystopexy (Marshall-Marchetti-Krantz type, Pereyra type) with or without endoscopic control	Nonlaparoscopic
58292	Vaginal hysterectomy, for uterus greater than 250 g; with removal of tube(s) and/or ovary(s), with repair of enterocele	Nonlaparoscopic
58275	Vaginal hysterectomy, with total or partial vaginectomy	Nonlaparoscopic
58285	Vaginal hysterectomy, radical (Schauta type operation)	Nonlaparoscopic
58280	Vaginal hysterectomy, with total or partial vaginectomy; with repair of enterocele	Nonlaparoscopic
58294	Vaginal hysterectomy, for uterus greater than 250 g; with repair of enterocele	Nonlaparoscopic
58293	Vaginal hysterectomy, for uterus greater than 250 g; with colpo-urethrocystopexy (Marshall-Marchetti-Krantz type, Pereyra type) with or without endoscopic control	Nonlaparoscopic
58150	Total abdominal hysterectomy (corpus and cervix), with or without removal of tube(s), with or without removal of ovary(s)	Nonlaparoscopic
58180	Supracervical abdominal hysterectomy (subtotal hysterectomy), with or without removal of tube(s), with or without removal of ovary(s)	Nonlaparoscopic
58210	Radical abdominal hysterectomy, with bilateral total pelvic lymphadenectomy and para-aortic lymph node sampling (biopsy), with or without removal of tube(s), with or without removal of ovary(s)	Nonlaparoscopic
58953	Bilateral salpingo-oophorectomy with omentectomy, total abdominal hysterectomy and radical dissection for debulking	Nonlaparoscopic
58954	Bilateral salpingo-oophorectomy with omentectomy, total abdominal hysterectomy and radical dissection for debulking; with pelvic lymphadenectomy and limited para-aortic lymphadenectomy	Nonlaparoscopic
58956	Bilateral salpingo-oophorectomy with total omentectomy, total abdominal hysterectomy for malignancy	Nonlaparoscopic
58200	Total abdominal hysterectomy, including partial vaginectomy, with para-aortic and pelvic lymph node sampling, with or without removal of tube(s), with or without removal of ovary(s)	Nonlaparoscopic
58951	Resection (initial) of ovarian, tubal or primary peritoneal malignancy with bilateral salpingo-oophorectomy and omentectomy; with total abdominal hysterectomy, pelvic and limited para-aortic lymphadenectomy	Nonlaparoscopic
58152	Total abdominal hysterectomy (corpus and cervix), with or without removal of tube(s), with or without removal of ovary(s); with colpo-urethrocystopexy (eg, Marshall-Marchetti-Krantz, Burch)	Nonlaparoscopic
58240	Pelvic exenteration for gynecologic malignancy, with total abdominal hysterectomy or cervicectomy, with or without removal of tube(s), with or without removal of ovary(s), with removal of bladder and ureteral transplantations, and/or abdominoperineal resection of rectum and colon and colostomy, or any combination thereof	Nonlaparoscopic
	Incisional and Other Ventral Hernia Repair	
49560	Repair initial incisional or ventral hernia; reducible	Nonlaparoscopic
49652	Laparoscopy, surgical, repair, ventral, umbilical, spigelian or epigastric hernia (includes mesh insertion, when performed); reducible	Laparoscopic

CPT Code	Description	Laparoscopic or Nonlaparoscopic
49561	Repair initial incisional or ventral hernia; incarcerated or strangulated	Nonlaparoscopic
49653	Laparoscopy, surgical, repair, ventral, umbilical, spigelian or epigastric hernia (includes mesh insertion, when performed); incarcerated or strangulated	Laparoscopic
49565	Repair recurrent incisional or ventral hernia; reducible	Nonlaparoscopic
49566	Repair recurrent incisional or ventral hernia; incarcerated or strangulated	Nonlaparoscopic
49585	Repair umbilical hernia, age 5 years or older; reducible	Nonlaparoscopic
49587	Repair umbilical hernia, age 5 years or older; incarcerated or strangulated	Nonlaparoscopic
49580	Repair umbilical hernia, younger than age 5 years; reducible	Nonlaparoscopic
49582	Repair umbilical hernia, younger than age 5 years; incarcerated or strangulated	Nonlaparoscopic
49654	Laparoscopy, surgical, repair, incisional hernia (includes mesh insertion, when performed); reducible	Laparoscopic
49655	Laparoscopy, surgical, repair, incisional hernia (includes mesh insertion, when performed); incarcerated or strangulated	Laparoscopic
49656	Laparoscopy, surgical, repair, recurrent incisional hernia (includes mesh insertion, when performed); reducible	Laparoscopic
49657	Laparoscopy, surgical, repair, recurrent incisional hernia (includes mesh insertion, when performed); incarcerated or strangulated	Laparoscopic
49570	Repair epigastric hernia (eg, preperitoneal fat); reducible (separate procedure)	Nonlaparoscopic
49572	Repair epigastric hernia (eg, preperitoneal fat); incarcerated or strangulated	Nonlaparoscopic
49590	Repair spigelian hernia (lateral ventral hernia)	Nonlaparoscopic
	Inguinal and Femoral Hernia Repair	
49505	Repair initial inguinal hernia, age 5 years or older; reducible	Nonlaparoscopic
49650	Laparoscopy, surgical; repair initial inguinal hernia	Laparoscopic
49507	Repair initial inguinal hernia, age 5 years or older; incarcerated or strangulated	Nonlaparoscopic
49520	Repair recurrent inguinal hernia, any age; reducible	Nonlaparoscopic
49651	Laparoscopy, surgical; repair recurrent inguinal hernia	Laparoscopic
49500	Repair initial inguinal hernia, age 6 months to younger than 5 years, with or without hydrocelectomy; reducible	Nonlaparoscopic
49525	Repair inguinal hernia, sliding, any age	Nonlaparoscopic
49521	Repair recurrent inguinal hernia, any age; incarcerated or strangulated	Nonlaparoscopic
49495	Repair, initial inguinal hernia, full term infant younger than age 6 months, or preterm infant older than 50 weeks postconception age and younger than age 6 months at the time of surgery, with or without hydrocelectomy; reducible	Nonlaparoscopic
49491	Repair, initial inguinal hernia, preterm infant (younger than 37 weeks gestation at birth), performed from birth up to 50 weeks postconception age, with or without hydrocelectomy; reducible	Nonlaparoscopic

CPT Code	Description	Laparoscopic or Nonlaparoscopic
49501	Repair initial inguinal hernia, age 6 months to younger than 5 years, with or without hydrocelectomy; incarcerated or strangulated	Nonlaparoscopic
49496	Repair, initial inguinal hernia, full term infant younger than age 6 months, or preterm infant older than 50 weeks postconception age and younger than age 6 months at the time of surgery, with or without hydrocelectomy; incarcerated or strangulated	Nonlaparoscopic
49492	Repair, initial inguinal hernia, preterm infant (younger than 37 weeks gestation at birth), performed from birth up to 50 weeks postconception age, with or without hydrocelectomy; incarcerated or strangulated	Nonlaparoscopic
49550	Repair initial femoral hernia, any age; reducible	Nonlaparoscopic
49553	Repair initial femoral hernia, any age; incarcerated or strangulated	Nonlaparoscopic
49555	Repair recurrent femoral hernia; reducible	Nonlaparoscopic
49557	Repair recurrent femoral hernia; incarcerated or strangulated	Nonlaparoscopic
	Myomectomy	
58545	Laparoscopy, surgical, myomectomy, excision; 1 to 4 intramural myomas with total weight of 250 g or less and/or removal of surface myomas	Laparoscopic
58546	Laparoscopy, surgical, myomectomy, excision; 5 or more intramural myomas and/or intramural myomas with total weight greater than 250 g	Laparoscopic
58145	Myomectomy, excision of fibroid tumor(s) of uterus, 1 to 4 intramural myoma(s) with total weight of 250 g or less and/or removal of surface myomas; vaginal approach	Nonlaparoscopic
58140	Myomectomy, excision of fibroid tumor(s) of uterus, 1 to 4 intramural myoma(s) with total weight of 250 g or less and/or removal of surface myomas; abdominal approach	Nonlaparoscopic
58146	Myomectomy, excision of fibroid tumor(s) of uterus, 5 or more intramural myomas and/or intramural myomas with total weight greater than 250 g, abdominal approach	Nonlaparoscopic
	Oophorectomy	
58661	Laparoscopy, surgical; with removal of adnexal structures (partial or total oophorectomy and/or salpingectomy)	Laparoscopic
58720	Salpingo-oophorectomy, complete or partial, unilateral or bilateral (separate procedure)	Nonlaparoscopic
58940	Oophorectomy, partial or total, unilateral or bilateral;	Nonlaparoscopic
58950	Resection (initial) of ovarian, tubal or primary peritoneal malignancy with bilateral salpingo-oophorectomy and omentectomy;	Nonlaparoscopic
58952	Resection (initial) of ovarian, tubal or primary peritoneal malignancy with bilateral salpingo-oophorectomy and omentectomy; with radical dissection for debulking (ie, radical excision or destruction, intra-abdominal or retroperitoneal tumors)	Nonlaparoscopic
58943	Oophorectomy, partial or total, unilateral or bilateral; for ovarian, tubal or primary peritoneal malignancy, with para-aortic and pelvic lymph node biopsies, peritoneal washings, peritoneal biopsies, diaphragmatic assessments, with or without salpingectomy(s), with or without omentectomy	Nonlaparoscopic

CPT Code	Description	Laparoscopic or Nonlaparoscopic
	Paraesophageal Hernia Repair and Esophagogastric Fundoplasty	
43281	Laparoscopy, surgical, repair of paraesophageal hernia, includes fundoplasty, when performed; without implantation of mesh	Laparoscopic
43282	Laparoscopy, surgical, repair of paraesophageal hernia, includes fundoplasty, when performed; with implantation of mesh	Laparoscopic
43332	Repair, paraesophageal hiatal hernia (including fundoplication), via laparotomy, except neonatal; without implantation of mesh or other prosthesis	Nonlaparoscopic
43333	Repair, paraesophageal hiatal hernia (including fundoplication), via laparotomy, except neonatal; with implantation of mesh or other prosthesis	Nonlaparoscopic
43336	Repair, paraesophageal hiatal hernia, (including fundoplication), via thoracoabdominal incision, except neonatal; without implantation of mesh or other prosthesis	Nonlaparoscopic
43334	Repair, paraesophageal hiatal hernia (including fundoplication), via thoracotomy, except neonatal; without implantation of mesh or other prosthesis	Nonlaparoscopic
43337	Repair, paraesophageal hiatal hernia, (including fundoplication), via thoracoabdominal incision, except neonatal; with implantation of mesh or other prosthesis	Nonlaparoscopic
43335	Repair, paraesophageal hiatal hernia (including fundoplication), via thoracotomy, except neonatal; with implantation of mesh or other prosthesis	Nonlaparoscopic
43280	Laparoscopy, surgical, esophagogastric fundoplasty (eg, Nissen, Toupet procedures)	Laparoscopic
43325	Esophagogastric fundoplasty, with fundic patch (Thal-Nissen procedure)	Nonlaparoscopic
43327	Esophagogastric fundoplasty partial or complete; laparotomy	Nonlaparoscopic
43328	Esophagogastric fundoplasty partial or complete; thoracotomy	Nonlaparoscopic
	Prostatectomy	
55873	Cryosurgical ablation of the prostate (includes ultrasonic guidance and monitoring)	Nonlaparoscopic
55866	Laparoscopy, surgical prostatectomy, retropubic radical, including nerve sparing, includes robotic assistance, when performed	Laparoscopic
55845	Prostatectomy, retropubic radical, with or without nerve sparing; with bilateral pelvic lymphadenectomy, including external iliac, hypogastric, and obturator nodes	Nonlaparoscopic
55840	Prostatectomy, retropubic radical, with or without nerve sparing	Nonlaparoscopic
55842	Prostatectomy, retropubic radical, with or without nerve sparing; with lymph node biopsy(s) (limited pelvic lymphadenectomy)	Nonlaparoscopic
55831	Prostatectomy (including control of postoperative bleeding, vasectomy, meatotomy, urethral calibration and/or dilation, and internal urethrotomy); retropubic, subtotal	Nonlaparoscopic
55810	Prostatectomy, perineal radical	Nonlaparoscopic

CPT Code	Description	Laparoscopic or Nonlaparoscopic
55821	Prostatectomy (including control of postoperative bleeding, vasectomy, meatotomy, urethral calibration and/or dilation, and internal urethrotomy); suprapubic, subtotal, 1 or 2 stages	Nonlaparoscopic
55812	Prostatectomy, perineal radical; with lymph node biopsy(s) (limited pelvic lymphadenectomy)	Nonlaparoscopic
55815	Prostatectomy, perineal radical; with bilateral pelvic lymphadenectomy, including external iliac, hypogastric and obturator nodes	Nonlaparoscopic
55801	Prostatectomy, perineal, subtotal (including control of postoperative bleeding, vasectomy, meatotomy, urethral calibration and/or dilation, and internal urethrotomy)	Nonlaparoscopic
	Pyeloplasty	
50400	Pyeloplasty (Foley Y-pyeloplasty), plastic operation on renal pelvis, with or without plastic operation on ureter, nephropexy, nephrostomy, pyelostomy, or ureteral splinting; simple	Nonlaparoscopic
50405	Pyeloplasty (Foley Y-pyeloplasty), plastic operation on renal pelvis, with or without plastic operation on ureter, nephropexy, nephrostomy, pyelostomy, or ureteral splinting; complicated (congenital kidney abnormality, secondary pyeloplasty, solitary kidney, calycoplasty)	Nonlaparoscopic
50544	Laparoscopy, surgical; pyeloplasty	Laparoscopic

CPT indicates Current Procedural Terminology.