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Minimally Invasive Surgery in the United States, 2022: Understanding Its Value Using New Datasets

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Abstract

Introduction: While minimally invasive surgery (MIS) has transformed the treatment landscape of surgical care, its utilization is not well understood. The newly released Nationwide Ambulatory Surgery Sample allows for more accurate estimates of MIS volume in the United States—in combination with inpatient datasets.

Materials and methods: Multiple nationwide databases from the Healthcare Cost and Utilization Project (HCUP) were used: the Nationwide Ambulatory Surgery Sample and National Inpatient Sample. The volume of MIS and robotic procedures were calculated from 2016 to 2018. An online query system, HCUPNet, was queried for inpatient stays from 1993 to 2014.

Results: In 2017, 9.8 million inpatient major operating room procedures were analyzed, of which 11.1% were MIS and 2.5% were robotic-assisted, compared with 9.6 million inpatient operating room procedures (11.2% MIS and 2.9% robotic-assisted) in 2018. There were 10.6, 10.6, and 10.7 million ambulatory procedures in 2016, 2017, and 2018, respectively. Ambulatory MIS procedures showed an increasing trend across years, representing 16.9%, 17.4%, and 18%, respectively. HCUPNet data revealed an increase in inpatient MIS cases from 529,811 (8.9%) in 1993 to 1,443,446 (20.7%) in 2014.

Conclusions: This study is the first to estimate national MIS volume across specialties in both inpatient and ambulatory hospital settings. We found a trend toward a higher proportion of MIS and robotic cases from 1997 to 2018. These data may help contribute to a more

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Supplementary Materials

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jss.2022.08.006>.

Disclosure

Dr Holsinger is a co-founder of Photonic Medical, has consulted with Lumenis Laser, Boston Scientific, Spiro Robotics, Intuitive, and Cambridge Medical Robotics.

comprehensive understanding of MIS value within surgery and highlight limitations of current databases, especially when categorizing robotic cases on a national scale.

Keywords

Ambulatory surgery; HCUP; Minimally invasive surgery; NASS; NIS; Robotic-assisted

Introduction

Minimally invasive surgery (MIS) has transformed the treatment landscape of surgical care and improved patient outcomes by reducing postoperative pain, complications, length of hospital stay, and readmissions.^{1,2} Several fields have shown lower Medicare costs with MIS² but these analyses excluded ambulatory procedures because of limited data availability. To our knowledge, there is no current estimate of MIS ambulatory volume in the United States despite its considerable impact on clinical practice and patient outcomes in recent decades. As technique improves, it may be that previously inpatient cases could become ambulatory.

The Agency for Health Research and Quality (AHRQ) has several databases through the Healthcare Cost and Utilization Project (HCUP)³ that provides information on MIS, including the longstanding National Inpatient Sample (NIS) and state databases. In 2020, AHRQ released the Nationwide Ambulatory Surgery Sample (NASS),⁴ combining previously fractured state databases and allowing researchers to better evaluate post-2016 ambulatory surgeries on a national scale. This creates a complementary dataset to the existing NIS dataset to review for the first time.

We aimed to leverage NIS, NASS, and HCUPNet—a free online query system from HCUP—to characterize recent US trends in MIS across all surgical settings to provide a context for the role of MIS in healthcare, including, to our knowledge, the first estimate of ambulatory MIS volume.

Methods

HCUP provides longitudinal hospital care data on a national scale that can be used to investigate trends related to inpatient stays, emergency department visits, and ambulatory care. In this study, we used three different data sources within HCUP which all together include data from years 1993–2018 and have unique procedure coding properties as described below and demonstrated in the supplement (Table S1).

Inpatient data were obtained from the NIS.⁴ We created a subset of hospital stays from 2017 to 2018 NIS data using the International Classification of Diseases (ICD), Tenth Revision (ICD-10-PCS) and applied the “HCUP Procedure Classes Refined for ICD-10-PCS” software tool to isolate encounters with major operating room procedures (as defined by AHRQ). An MIS procedure list of ICD-10-PCS codes including laparoscopic, thoracoscopic, and robotic codes was used to stratify encounters.

Ambulatory encounters were obtained from the NASS and were isolated using Current Procedural Terminology (CPT) codes. Statistical analysis was completed using previously published HCUP survey methods⁵ with SAS 9.4 (SAS Institute Inc, Cary, North Carolina).

In addition, public data from the HCUP online query system, HCUPNet,⁶ were reviewed to estimate broader trends in MIS procedures. We queried for inpatient stays from 1993 to 2014 with ICD-9-PCS procedure codes indicating MIS procedures (laparoscopic, thoracoscopic, or robotic) that were available in the HCUPNet system. ICD-9 codes were cross-walked to ICD-10 codes used in NIS. Using the “HCUP Fast Stats–Trends in Inpatient Stays” tool, we queried the number of surgical hospitalizations between 1993 and 2014. Finally, we calculated the percent of annual surgical discharges involving MIS procedures using the first value (inpatient stays involving MIS) as a numerator and the second (total surgical hospitalizations) as a denominator. This study was approved by the Stanford University Institutional Review Board.

Results

We analyzed a weighted total of 9.8 million inpatient major operating room procedures in 2017 and 9.6 million in 2018 (Table 1). In 2017, 11.1% of these procedures were minimally invasive (95% confidence interval [CI] 10.9%–11.3%) and 2.5% were robotic-assisted (95% CI 2.4%–2.6%); in 2018, these rates were 11.2% (95% CI 10.9%–11.4%) and 2.9% (95% CI 2.7%–3.0%), respectively. The most common MIS cases were laparoscopic cholecystectomy, appendectomy, vertical (sleeve) gastrectomy, gastric bypass, and prostatectomy (Table S2).

In the ambulatory setting, MIS procedures were more frequent and represented a larger proportion of overall ambulatory operations. In 2016, 2017, and 2018, the total surgical encounters were 10.6, 10.6, and 10.7 million, respectively (Table 2). The proportion of encounters with an MIS procedure was 16.9% (95% CI: 16.5–17.3), 17.4% (95% CI: 17.0–17.8), and 18% (95% CI: 17.6–18.4) in 2016, 2017, and 2018, respectively. Laparoscopic cholecystectomy and appendectomy were most common, followed by laparoscopic total hysterectomy, inguinal hernia repair, and oophorectomy and/or salpingectomy. In these NASS data, level II CPT codes associated with robotic procedures are not yet included; therefore, the fraction of robotic MIS procedures remains unknown.

HCUPNet data from 1993 to 2014 were analyzed to add historical context, showing that the annual number of hospital discharges involving an MIS case increased from 529,811 to 1,443,446 over that period, representing 8.9% and 20.7% of all surgical hospitalizations, respectively.

Discussion

In this study, using HCUP data, we calculated an annual volume of more than three million MIS cases in the United States. We found that more than one in 10 inpatient surgeries and almost one in five outpatient surgeries were considered MIS in 2017 and 2018 while nearly 3% of operations were robotic-assisted. We also found that the annual volume of inpatient MIS cases more than doubled over the period from 1993 to 2014. While there is

a discrepancy in the percentage of inpatient MIS in 2014 from HCUPNet and post-2016 values in NIS, this likely does not represent a true decline in MIS but rather the differences between ICD-9 and ICD-10 coding schema and sampling differences. In our analysis of the most recent years available, 2016–2018, we observed a trend toward higher MIS volume in the ambulatory settings, but this did not reach statistical significance in the short interval.

Data on this topic have been limited, especially before the NASS was available, but our results are consistent with prior findings. Prior NIS studies have shown a four-fold increase in inpatient robotic general surgery procedures from 2010 to 2014,⁷ with 4.5% overall being robotic. Separate findings reveal a subsequently eight-fold increase from 2012 to 2018 in robotic general surgery in the United States.⁸ Ambulatory data on MIS have been limited, however, and our data are the first to our knowledge estimating this figure using the NASS.

This study has several limitations to acknowledge, almost all of which stem from the inherently flawed nature of administrative claims data. First, NASS is limited to hospital-owned facilities; other ambulatory centers may be less inclined to invest in equipment for MIS. Second, NASS does not have patient comorbidity data which could help explain the choice of MIS and does not include level II CPT codes (e.g., S2900) to create a robotic subset of procedures with CPT. Third, comparisons to pre-2015 data should be made with caution due to changes in ICD coding schemata; distinguishing surgical procedures can be more challenging using ICD-10 than CPT or ICD-9. Fourth, while there are not enough NASS data yet collected to make conclusions about trends in ambulatory surgery, these data provide baseline figures using rigorously collected survey data.

In this brief study, we quantify the expected increase in MIS and robotic cases from 1993 to 2018 across various datasets provided by HCUP, including a newly available ambulatory dataset. Fundamental data on national pan-specialty surgical volume such as these inform policy and investment choices and are critical to report and track. The lack of high-quality data on robotic cases is a notable absence and underscores the need for consistent and meaningful data collection to make data-informed policy conclusions regarding trends in this field of surgery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1 –

Total inpatient procedure stays by category, NIS database.

Visits with OR procedures	Unweighted total	Weighted total	(95% CI)	%	(95% CI)
2017					
Visits with 1 MIS procedure	217,067	1,085,334	(1,055,299–1,115,369)	11.1	(10.9–11.3)
Visits with 1 robotic-assisted	49,425	247,125	(233,374–260,876)	2.5	(2.4–2.6)
Total visits with OR procedure	1,958,445	9,792,219	(9,579,281–10,005,157)		
2018					
Visits with 1 MIS procedure	214,283	1,071,415	(1,041,805–1,101,025)	11.2	(10.9–11.4)
Visits with 1 robotic-assisted	55,265	276,325	(261,629–291,021)	2.9	(2.7–3.0)
Total visits with OR procedure	1,921,042	9,605,207	(9,393,154–9,817,259)		

Table 2 –

Total proportion of ambulatory surgery encounters with MIS (laparoscopic, thoracoscopic), NASS database.

Ambulatory surgery encounters	Unweighted total	Weighted total	(95% CI)	%	(95% CI)
2016					
Visits with 1 MIS procedure	1,279,252	1,800,349	(1,743,793–1,856,905)	16.9	(16.5–17.3)
Total visits	7,608,879	10,623,113	(10,300,889–10,945,337)		
2017					
Visits with 1 MIS procedure	1,311,328	1,836,254	(1,779,245–1,893,263)	17.4	(17.0–17.8)
Total visits	7,647,636	10,570,649	(10,251,453–10,889,845)		
2018					
Visits with 1 MIS procedure	1,364,055	1,921,850	(1,858,501–1,985,199)	18.0	(17.6–18.4)
Total visits	7,693,084	10,696,113	(10,357,508–11,034,754)		