BRIEF REPORT

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Comparison of peroral endoscopic myotomy, laparoscopic Heller myotomy, and pneumatic dilation for patients with achalasia: a United States national experience

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Achalasia is a rare neurodegenerative disorder characterized by insufficient lower esophageal sphincter (LES) relaxation coupled with inefficient peristalsis, leading to functional obstruction at the gastroesophageal junction.[1] Globally, the prevalence of achalasia is around 9 per 100,000 persons.[2] Management of achalasia is focused on symptom control and maintenance of nutritional status.[1-3] Pneumatic dilation (PD), peroral endoscopic myotomy (POEM), and laparoscopic Heller myotomy (LHM) are viable treatment options that are frequently employed for managing achalasia.[1,3,4] In the United States (US), achalasia-related hospitalizations and readmissions are on the rise, with healthcare costs estimated to exceed $408 million in 2018.[5] Nevertheless, there continues to be a substantial paucity of data on clinical outcomes of PD, POEM, and LHM among patients hospitalized for achalasia in the US. Hence, this study was designed to assess and compare readmission rates, hospitalization outcomes, adverse events, requirements for repeat procedures, and healthcare utilization for achalasia hospitalizations undergoing PD, POEM, and LHM in the US.

This study derived data from the Nationwide Readmissions Database (NRD), which is one of the largest, publicly available, multi-ethnic readmission databases in the US. For each calendar year, NRD contains weighted discharge information from US states, which can be used to derive national estimates. Within the database, patients are tracked using unique identifier numbers that are not linked to patient or hospital data. Hence, all data are de-identified to maintain patient privacy. We utilized the NRD from 2016-2020 to identify all adult (≥18 years) hospitalizations with a principal diagnosis of achalasia and those with a principal diagnosis of dysphagia, esophageal obstruction, food impaction, or aspiration pneumonia combined with a coexisting diagnosis of achalasia. Among these admissions, patients undergoing PD, POEM, and LHM were identified. Patients <18 years of age and those with esophageal or gastric cancer were excluded from this study. For the 2016-2020 years, the NRD was coded using the International Classification of Diseases, Tenth Revision codes. Analysis was performed using Stata ver. 18 software (StataCorp) using weighted samples for national estimates. Patients in the LHM and PD cohorts were compared with those in the POEM cohort. A univariate regression analysis was performed with outcomes as dependent variables and potential confounders as independent predictors. A p-value of 0.2 was considered to imply a possible association, and these variables were adjusted for in the multivariate regression model. A multivariate regression analysis was per-

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formed to calculate the odds of all-cause readmission, inpatient mortality, mean length of stay (LOS), and mean total hospital charge (THC) after adjusting for age, sex, type of insurance, mean household income, hospital characteristics, and medical comorbidities (i.e., heart failure, hypertension, renal disease, tobacco use, malnutrition, and chronic obstructive pulmonary disease were found to be significantly associated confounders), as well as Charlson comorbidity index (CCI). THC from 2016-2020 was adjusted for inflation in the healthcare sector using the consumer price index inflation calculator maintained by the US Bureau of Labor Statistics. Multivariate linear and logistic regression were used to compare continuous and categorical variables, respectively. A 2-sided $p<0.05$ was considered to represent statistical significance. The NRD lacks patient and hospital-specific identifiers. Therefore, institutional review board approval was not required. The NRD lacks specific patient identifiers. Hence, patient consent was not required.

Between 2016 and 2020, there were 2,922 PD, 2,343 POEM, and 11,345 LHM procedures performed for 16,610 index achalasia admissions in the US. All-cause 30-day readmission rates were 12.34, 4.28, and 3.63% for the PD, POEM, and LHM cohorts, respectively. Patients with achalasia who underwent PD had significantly higher odds of readmission than those in the POEM cohort (odds ratio [OR], 2.48; 95% confidence interval [CI], 1.72–3.58; $p<0.001$). We did not detect a statistical difference in readmission rates between POEM and LHM cohorts.

Furthermore, we did detect any statistically significant difference in all-cause mortality rates between POEM and PD (0.2% vs. 1.08%; adjusted ORs [aOR], 1.71; 95% CI 0.34–8.61; $p=0.514$) and POEM and LHM cohorts (0.2% vs. 0.16%; aOR, 1.40; 95% CI, 0.20–9.83; $p=0.733$). However, patients in the PD cohort had a longer mean LOS than those in the POEM cohort (6.43 vs. 3.2 days, differences on regression 2.07 days; 95% CI, 1.54–2.6; $p<0.001$) on index admission. The difference in the LOS between the POEM and LHM cohorts was not statistically significant.

After adjusting for confounders, compared with patients in the POEM cohort, patients in the PD cohort exhibited significantly higher odds for the need for blood transfusion (0.7% vs. 2.27%; aOR, 2.16; 95% CI, 1.02–4.55; $p=0.043$) and intensive care unit (ICU) care (1.52% vs. 3.86%; aOR, 2.12; 95% CI, 1.12–4.02; $p=0.02$). Additionally, patients in the PD cohort had higher odds for esophageal perforation, periprocedural hemorrhage, and sepsis than those in the POEM cohort; however, after adjusting for confounders, these differences were non-significant. The POEM and LHM cohorts showed no significant differences in the odds for needing blood transfusion, ICU care, esophageal perforation, periprocedural hemorrhage, and sepsis. Figure 1 summarizes the periprocedural adverse events.

Upon readmission, a higher proportion (16.2%) of patients in the PD cohort underwent additional procedures. Of these, 8.49% underwent repeat PD, 7.33% underwent LHM, and 0.38% underwent POEM. Conversely, a relatively smaller proportion of patients undergoing POEM (5.66%) and LHM (3.61%) required additional procedures on readmission. Hospitalization characteristics and a summary of findings are out-

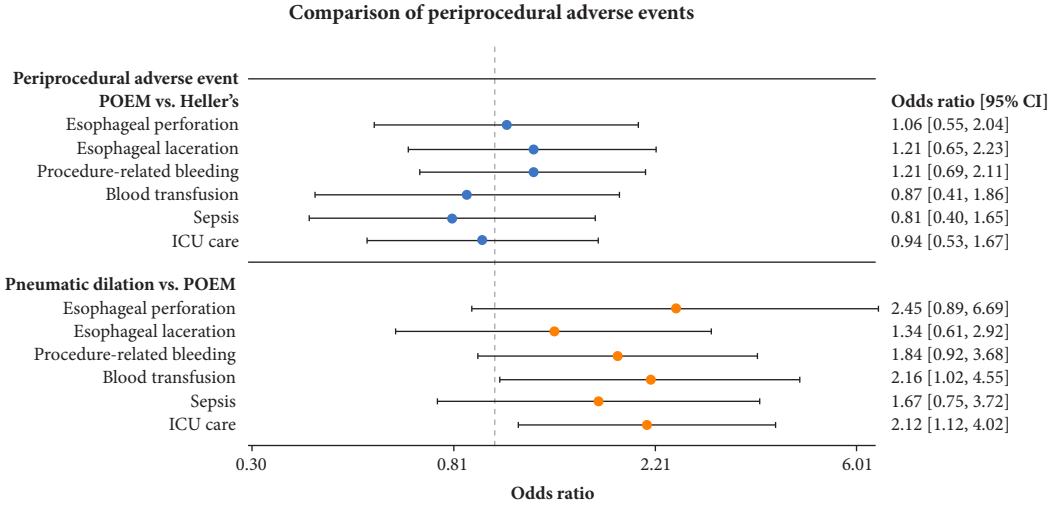

Fig. 1. Comparison of periprocedural adverse events among pneumatic dilation, peroral endoscopic myotomy (POEM), and laparoscopic Heller myotomy.

Table 1. Baseline hospitalization characteristics, comparison of 30-day readmission rates, and requirement of additional procedures on readmission for achalasia patients that underwent POEM, LHM, and PD in the United States between 2016–2020

	POEM (*n*=2,343)	LHM (*n*=11,345)	PD (*n*=2,922)	*p*-value
Mean age (range)	58.64 (57.58–59.71)	56.43 (55.93–56.93)	68.39 (67.35–69.44)	
Sex				
Male	1,148 (49.0)	5,803 (51.2)	1,369 (46.9)	0.011
Female	1,196 (51.0)	5,542 (48.8)	1,552 (53.1)	
Charlson comorbidity index				
0	1,254 (53.5)	6,830 (60.2)	949 (32.5)	<0.001
1	593 (25.3)	2,586 (22.8)	702 (24.0)	
2	246 (10.5)	1,035 (9.1)	524 (17.9)	
3 or more	250 (10.7)	895 (7.9)	747 (25.6)	
Comorbidities				
Congestive heart failure	123 (5.2)	434 (3.8)	491 (16.8)	<0.001
Renal disease	163 (7.0)	586 (5.2)	497 (17.0)	<0.001
Chronic obstructive pulmonary disease	244 (10.4)	989 (8.7)	542 (18.5)	<0.001
Diabetes mellitus	431 (18.4)	1,729 (15.2)	697 (23.9)	<0.001
Morbid obesity	122 (5.2)	666 (5.9)	153 (5.2)	0.505
Smoking	228 (9.7)	1,238 (10.9)	359 (12.3)	0.147
Malnutrition	267 (11.4)	779 (6.9)	622 (21.3)	<0.001
Hospital location				
Metropolitan	2,337 (99.7)	11,085 (97.7)	2,781 (95.2)	<0.001
Micropolitan	6 (0.3)	227 (2.0)	110 (3.8)	
Non-urban	0 (0)	33 (0.3)	31 (1.1)	
Hospital teaching status				
Metropolitan non-teaching	54 (2.3)	1,059 (9.3)	588 (20.1)	<0.001
Metropolitan teaching	2,284 (97.5)	10,026 (88.4)	2,192 (75.0)	
Micropolitan	6 (0.3)	260 (2.3)	141 (4.8)	
Hospital Size				
Small	122 (5.2)	981 (8.6)	431 (14.8)	<0.001
Medium	225 (9.6)	2,076 (18.3)	642 (22.0)	
Large	1,997 (85.2)	8,289 (73.1)	1,848 (63.2)	
Insurance				
Medicare	1,081 (46.1)	4,804 (42.3)	2,004 (68.6)	<0.001
Medicaid	242 (10.3)	1,240 (10.9)	293 (10.0)	
Private insurance	884 (37.7)	4,607 (40.6)	456 (15.6)	
Self-pay	48 (2.0)	245 (2.2)	93 (3.2)	
Median household income				
Quartile 1	483 (20.6)	2,849 (25.1)	927 (31.7)	<0.001
Quartile 2	538 (23.0)	3,108 (27.4)	791 (27.1)	
Quartile 3	577 (24.6)	3,013 (26.6)	666 (22.8)	
Quartile 4	716 (30.6)	2,206 (19.4)	494 (16.9)	
Disposition				
Home	2,114 (90.2)	10,402 (91.7)	1,879 (64.3)	<0.001
Short-term care facility	7 (0.3)	10 (0.1)	23 (0.8)	
Senior nursing facility	68 (2.9)	297 (2.6)	489 (16.7)	
Home health care	142 (6.1)	600 (5.3)	472 (16.2)	
Discharge against medical advice	6 (0.3)	11 (0.1)	26 (0.9)	
Repeat procedure at readmission				
POEM	0 (0)	0 (0)	1 (0)	
LHM	3 (0.1)	2 (0)	26 (0.9)	
PD	3 (0.1)	13 (0)	30 (1.0)	
Comparison of 30-day readmission rates				
POEM	97 (4.1)[a]	Reference		
LHM	405 (17.3)[a]	0.84 (0.61–1.15)		0.289
PD	357 (15.2)[a]	2.48 (1.72–3.58)		<0.001

Values are presented as number (%) or adjusted odds ratio (95% confidence interval) unless otherwise indicated.
POEM, peroral endoscopic myotomy; LHM, laparoscopic Heller myotomy; PD, pneumatic dilation.
[a] 30-Day readmission rate.

lined in Tables 1 and 2.

The reasons for 30-day readmissions differed significantly between the three cohorts. In the PD cohort, 37.03% of all 30-day readmissions were for achalasia management, compared with 14.76% and 9.49% in the LHM and POEM cohorts, respectively. Table 3 highlights the other commonly identified causes of readmission.

Our study provides therapeutic endoscopists with a bird's-eye view of US-based hospitalization data among patients undergoing PD, POEM, and LHM for achalasia. In our study, LHM was the most common procedure performed. Patients undergoing LHM and POEM had comparable 30-day readmission rates, all-cause mortality, odds of complications, LOS, and THC; however, we noted higher rates of these outcomes in the PD cohort. Furthermore, patients in the PD cohort required additional interventions upon readmission.

Between 2016 and 2017, Gupta et al.[6] reported that the 30-day readmission rates of PD, POEM, and LHM were 25.6, 6.67, and 5.99%, respectively, without statistically significant differences in the odds of readmission between POEM and LHM. Similarly, Haseeb et al.[7] (2016–2019) did not detect a difference in the odds of readmission between achalasia hospitalizations that underwent POEM and LHM. However, the authors reported substantially lower 30-day readmission rates for POEM (4.3%) and LHM (3.9%) than those reported previously, while the 30-day readmission rate for PD was markedly higher at 12.6%.[7] Our results are also in line with these findings, given the 30-day readmission rates of 12.34, 4.28, and 3.63% for the PD, POEM, and LHM cohorts, respectively, between 2016 and 2020.

Table 3. Most commonly identified reasons for 30-day readmission in achalasia patients undergoing POEM, LHM, and PD in the United States, 2016–2020

Cause of readmission	Proportion of readmissions (%)
POEM	
Gastrointestinal hemorrhage	9.49
Unspecified post-procedural complication of the digestive system	7.84
Achalasia	7.48
Vomiting with dehydration and acute kidney injury	6.91
Sepsis	5.87
LHM	
Achalasia	14.76
Vomiting with dehydration and acute kidney injury	9.59
Sepsis	5.80
Abdominal pain	5.54
Aspiration pneumonia	5.44
PD	
Achalasia	37.03
Aspiration pneumonia	8.78
Sepsis	6.67
Vomiting with dehydration and acute kidney injury	5.33
Esophageal ulcer and bleeding	4.01

POEM, peroral endoscopic myotomy; LHM, laparoscopic Heller myotomy; PD, pneumatic dilation.

Table 2. Outcomes for achalasia patients that underwent POEM, LHM, and PD in the United States between 2016–2020

Outcome	POEM (*n*=2,343)	LHM (*n*=11,345)[a]/PD (*n*=2,922)[b]	OR (95% CI)	*p*-value
Esophageal perforation	27 (0.68)	125 (1.05)[a]	1.06 (0.55–2.04)	0.845
Puncture or laceration	36 (1.45)	203 (1.73)[a]	1.21 (0.65–2.23)	0.54
Hemorrhage	57 (2.19)	276 (2.29)[a]	1.21 (0.69–2.11)	0.496
Blood transfusion	17 (0.7)	56 (0.49)[a]	0.87 (0.41–1.86)	0.727
Sepsis	25 (0.94)	74 (0.64)[a]	0.81 (0.40–1.65)	0.577
Intensive care unit care	42 (1.52)	152 (1.25)[a]	0.94 (0.53–1.67)	0.855
Mortality	5 (0.2)	19 (0.16)[a]	1.40 (0.20–9.83)	0.733
Mean length of stay (day)	3.2	2.99[a]	0.024 (–0.32 to 0.37)	0.889
Total hospitalization charges (USD)	67,153	68,486[a]	1,882 (–6,814 to 1,0578)	0.671
Esophageal perforation	27 (0.68)	33 (1.13)[b]	2.45 (0.89–6.69)	0.08
Puncture or laceration	36 (1.45)	39 (1.34)[b]	1.34 (0.61–2.92)	0.461
Hemorrhage	57 (2.19)	128 (4.38)[b]	1.84 (0.92–3.68)	0.081
Blood transfusion	17 (0.7)	66 (2.27)[b]	2.16 (1.02–4.55)	0.043
Sepsis	25 (0.94)	63 (2.15)[b]	1.67 (0.75–3.72)	0.201
Intensive care unit care	42 (1.52)	113 (3.86)[b]	2.12 (1.12–4.02)	0.02
Mortality	5 (0.2)	31 (1.08)[b]	1.71 (0.34–8.61)	0.514
Mean length of stay (day)	3.2	6.43[b]	2.07 (1.54–2.6)	<0.001
Total hospitalization charges (USD)	67,153	72,242[b]	–595 (–11,213 to 10,021)	0.912

POEM, peroral endoscopic myotomy; LHM, laparoscopic Heller myotomy; PD, pneumatic dilation; OR, odds ratio; CI, confidence interval.

Studies with long-term follow-ups have revealed that POEM is a highly effective and safe procedure for achalasia.[7-9] A recent national database study by Haseeb et al.[7] reported a mortality rate of 0% for POEM versus 1.8% for LHM. Hence, the authors concluded that POEM was safer than LHM.[7] Our study contradicts these findings. Although we noted that the POEM cohort had a higher all-cause mortality rate than the LHM cohort (0.2% vs. 0.16%, respectively), the difference between the two was not statistically significant.

From a complication perspective, PD was noted to have the highest odds of complications (Table 2), although these were comparable among patients in the POEM and LHM cohorts. We noted that the PD cohort also had higher odds of needing ICU care than the POEM cohort-a finding that has not been reported previously. These findings must be interpreted in light of the fact that the PD cohort had a higher proportion of patients with a high comorbidity burden (25.58% with a CCI score ≥3). Hence, it is plausible that after initial evaluation, these patients may have been deemed poor candidates for POEM or LHM, thereby undergoing PD for achalasia management.

Limitations of our study include its retrospective nature, inability to characterize outcomes based on achalasia subtypes, hospitalization course, pharmacological aspects, pre-procedural evaluations, as well as intra- and post-procedural data. Additionally, as NRD is an administrative database, coding errors cannot be excluded. Owing to intrinsic limitations of the NRD database, data on the type of achalasia and intraprocedural mortality were unavailable. Additionally, the sample size of POEM limited our ability to perform subgroup analyses based on the year of procedure.

In conclusion, between 2016 and 2020 in the US, POEM and LHM had similar readmission, all-cause mortality, and complication rates, which are significantly lower than that for PD. We believe that careful patient selection for the management of achalasia is key to ensuring the best clinical outcomes and preventing adverse events.

Conflicts of Interest

The authors have no potential conflicts of interest.

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Author Contributions

Conceptualization: DSD, AR; Data curation: DSD, BSMP, SC, HA, MKG, AHS; Formal analysis: BSPM, MKG; Investigation: DSD, BSMP, SC, DY, AR; Methodology: DSD, BSMP; Project administration: DSD, BSMP, SC, AR; Resources: BSMP; Supervision: DSD, DY, ARL; Validation: all authors; Visualization: all authors; Writing–original draft: all authors; Writing–review & editing: all authors.

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