Original Article

Assessment of length of stay and cost of minimally invasive versus open thymectomies in patients with myasthenia gravis in Florida

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Background: Thymectomy has become a standard component in treatment for myasthenia gravis. The best surgical approach is still subject to debate. Minimally invasive surgery may have a lower mortality and morbidity rate, improved cosmetic results, and equivalent efficacy at improving neurologic symptoms to open approaches. We compared the perioperative outcomes and cost between the two techniques.

Methods: We queried Florida Inpatient Discharge Dataset for patients who underwent thymectomy and had a primary diagnosis of non-thymomatous myasthenia gravis using International Classification of Diseases (ICD)-9 and ICD-10 codes to carry out this retrospective cohort study. The dates ranged between January 1st, 2013, to December 31st, 2018. We compared outcomes of patients who underwent minimally invasive thymectomy versus those who had open thymectomy.

Results: An open approach was used in 108 patients, whereas a minimally invasive approach was used in 40 patients. Minimally invasive surgery group had a shorter length of stay (3.0 *vs.* 6.0 days, P<0.001) and had a non-significant lower total cost ($18.4K *vs.* $22.1K, P=0.186). After adjusting for age and Elixhauser score, length of stay for minimally invasive group was 32% (P=0.01) lower compared to the open surgery group.

Conclusions: Patients who underwent minimally invasive thymectomy for Myasthenia gravis had a significantly shorter length of stay and a lower, although not significant, overall cost.

Keywords: Thymectomy; video-assisted thoracic surgery (VATS); minimally invasive surgery (MIS); myasthenia gravis (MG); thoracic surgery

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Introduction

Until 2016, there was no class I evidence supporting thymectomy for myasthenia gravis (MG) patients. Wolfe *et al.* conducted the first randomized trial comparing the outcomes of trans-sternal thymectomy *vs.* medical treatment in patients with MG and demonstrated that thymectomy improved the quantitative MG score and reduced the need for Prednisone (1). Since then, thymectomy has become a standard component in the treatment for this disease (2-4). However, as all the thymectomies in the trial were performed through a sternotomy, there has been debate whether minimally invasive thymectomy produces the same neurologic symptom benefits compared to trans-sternal thymectomy.

Observational studies have shown that minimally invasive thymectomy for MG has a lower mortality and morbidity rate, improved cosmetic results, and equivalent efficacy to open approaches (5,6). Even so, some remain skeptical about these new techniques, arguing that surgical resection is more thorough with an open approach for negligible short-term differences (6,7).

This is the first statewide database study to compare hospital length of stay and charges of minimally invasive surgery (MIS) *vs.* open thymectomy in patients with MG. We present the following article in accordance with the STROBE reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-22-83/rc).

Methods

We queried the Florida Inpatient Discharge Dataset for patients who underwent thymectomy and had a primary diagnosis of non-thymomatous MG from January 1st, 2013 to December 31st, 2018 using International Classification of Diseases (ICD)-9 and ICD-10. Medicare patients under 65 were excluded as this group tends to be sicker for a variety of reasons. We compared those who had MIS thymectomy with those who had open thymectomy.

First, we filtered patients by procedure, including the following codes:

- MIS thymectomy: 07BM3ZZ (excision of thymus, percutaneous approach), 07BM4ZZ (resection of thymus, percutaneous endoscopic approach), 07.83 (thorascopic partial excision of thymus) and 07.84 (thorascopic total excision of thymus).
- Open thymectomy: 07BM0ZZ (excision of thymus, open approach), 07TM0ZZ (resection of thymus, open approach), 07.81 (other partial excision of thymus, open partial excision of thymus) and 07.82 (other total excision of thymus, open total excision of thymus) and 07.80 (thymectomy, not otherwise specified).

A total of 1,760 patients underwent the procedure between the dates mentioned above. We then selected only those patients with a primary admitting diagnosis of MG which were codes: G70.00, G70.01, 358, and 358.01. This resulted in 153 patients who underwent thymectomy for MG. Five patients were excluded due to missing or incomplete data from the dataset. A total of 148 patients were included.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). No institutional review board for this study was required as the data was collected from an insurance database and all patients were already de-identified.

Statistical analysis

Patient demographic characteristics, length of hospital stay, hospital volume, and total cost were compared between the open and MIS approaches. The Elixhauser Comorbidity Index, a method of categorizing patients' comorbidities based on the ICD, was calculated for patients from each group. Continuous variables were reported as means, standard deviations and medians; categorical variables were reported as counts and percentages. Subgroup analysis was performed using Chi-square test for categorical values and Kruskal-Wallis test for continuous variables. A hospital charge to cost ratio was applied to estimate total costs. All costs were inflated to 2019 US dollars. Cost of equipment and maintenance were excluded from the analysis to avoid bias. Multivariable linear models were used to evaluate the impact of surgery type on length of stay and total cost, with age and Elixhauser score adjusted. Log transformation was performed on both endpoints. Statistical analysis was performed with Bluesky software (Bluesky Statistics LLC, Chicago, IL, USA).

Results

An open approach was used in 108 patients, whereas a minimally invasive approach was used in 40 patients or 27% of the total. The MIS group patients were younger (41.2 *vs.* 48.5 years, P=0.031) and had a lower Elixhauser score (0.0 *vs.* 0.5, P=0.015) (*Table 1*).

Table 1 Demographic and clinical characteristics of patient population

Parameter	Minimally invasive surgery (N=40)	Open surgery (N=108)	Total (N=148)	P value
Gender, n (%)				0.625
Female	28 (70.0)	71 (65.7)	99 (66.9)	
Male	12 (30.0)	37 (34.3)	49 (33.1)	
Age, years				0.031
Mean (SD)	41.2 (19.1)	48.5 (18.5)	46.5 (18.9)	
Median	39.5	49.5	47.0	
Q1, Q3	28.5, 54.5	35.0, 63.0	32.0, 62.0	
Range	3.0–75.0	4.0–88.0	3.0–88.0	
Race, n (%)				0.574
Missing	4	7	11	
Non-White	12 (33.3)	39 (38.6)	51 (37.2)	
White	24 (66.7)	62 (61.4)	86 (62.8)	
Elixhauser score	40	108	148	0.015
Mean (SD)	0.0 (0.2)	0.5 (1.3)	0.4 (1.1)	
Median	0.0	0.0	0.0	
Q1, Q3	0.0, 0.0	0.0, 0.0	0.0, 0.0	
Range	0.0–1.0	0.0–6.0	0.0–6.0	
Insurance payer, n (%)				0.616
Commercial	20 (50.0)	59 (54.6)	79 (53.4)	
Non-commercial	20 (50.0)	49 (45.4)	69 (46.6)	
Patient region, n (%)				0.145
Missing	2	6	8	
Central	20 (52.6)	38 (37.3)	58 (41.4)	
North	6 (15.8)	13 (12.7)	19 (13.6)	
South	12 (31.6)	51 (50.0)	63 (45.0)	

SD, standard deviation; Q1, 25th percentile; Q3, 75th percentile.

We found that MIS was associated with a statistically significant reduced length of stay compared to open thymectomy (3.0 *vs.* 6.0 days, P<0.001). The mean cost of MIS was $9,746.8 less than the open but this was not statistically significant (*Table 2*).

As age and Elixhauser score were significantly different between the two groups, we included them in an adjusted logistic regression analysis. Length of stay for the MIS group was 0.68 times as long or 32% lower compared to the open surgery group (*Table 3*).

Total cost was less but not by a significant amount between the two groups in univariable or multivariable analysis (*Table 4*).

The rate of MIS versus open thymectomy stayed stable across our study period.

Discussion

Recommendations for thymectomy in patients with MG were made stronger in 2021 (8). The International Consensus Guidance for Management of MG now recommends early thymectomy in patients with non-

Table 2 Outcomes of open and minimally invasive thymectomies

Parameters	Minimally invasive surgery	Open surgery	Total	P value
Length of stay (days)				<0.001
N	40	108	148	
Mean (SD)	3.9 (2.7)	8.9 (8.6)	7.5 (7.8)	
Median (Q1, Q3)	3.0 (2.0, 5.0)	6.0	5.0	
Total cost (US dollar)				0.187
N	38	97	135	
Mean (SD)	20,092.5 (9,733.0)	29,839.3 (30,690.1)	27,095.8 (26,838.4)	
Median	18,431.1	22,121.0	20,563.3	
Q1, Q3	13,281.8, 22,871.8	12,489.7, 34,918.9	12,779.1, 32,450.1	
Range	6,693.6–56,484.5	7,297.7–252,771.4	6,693.6–252,771.4	

SD, standard deviation; Q1, 25th percentile; Q3, 75th percentile.

Table 3 Multivariate model predicting length of stay (with log transformation)

Parameter	Level	Coefficient (95% CI)	P value
Age	Per 1-year increase	0.00 (–0.01, 0.01)	0.82
Elixhauser score	Per 1-point increase	0.07 (–0.03, 0.17)	0.15
MIS group	Minimally invasive surgery	–0.39 (–0.70, –0.08)	0.01

CI, confidence interval; MIS, minimally invasive surgery.

Table 4 Multivariate model predicting total cost (with log transformation)

Parameter	Level	Coefficient (95% CI)	P value
Age	Per 1-year increase	–0.00 (–0.02, 0.02)	0.93
Elixhauser score	Per 1-point increase	0.09 (–0.20, 0.38)	0.53
MIS group	Minimally invasive surgery	–0.18 (–0.74, 0.38)	0.52

CI, confidence interval; MIS, minimally invasive surgery.

thymomatous generalized MG with acetylcholine receptor antibody (AChR-Ab) as it improves clinical outcomes, minimizes immunotherapy requirements, and lowers the need for hospitalization due to disease exacerbations. In the same document, the authors mention that MIS approaches to thymectomy are safe and yield similar results to more aggressive approaches (8). Although no randomized controlled studies have been carried out to date, most descriptive studies comparing MIS techniques with open approaches agree that either of them can be performed on a case-to-case basis (5,8-10) with their own benefits and downfalls.

MIS has shown to be superior to open thymectomy in terms of short-term outcomes. Analyzing a French database of patients with MG treated with thymectomy, Orsini *et al.* found that patients who underwent MIS thymectomy had a shorter hospital length of stay compared to open (4.5±2 *vs.* 7.7±4.5 days respectively, P<0.01) (11). In a single-center German study, Bachmann *et al.* also reported that patients who underwent a MIS thymectomy had a shorter hospital stay (10.5 days for MIS *vs.* 19 days for open, P<0.0001) (9). Our study reinforces this: the mean length of hospital stay was significantly lower in the MIS than in the open surgery group.

Another short-term outcome that should be compared is post-operative pain. Pain may inhibit breathing, coughing, and sputum expulsion increasing the risk of pulmonary atelectasis, infections, and myasthenic crisis (12). Fiorelli *et al.* demonstrated that patients who underwent MIS thymectomy had lower post-operative pain scores in the visual analog scale (1.9±0.8 for MIS *vs.* 3.7±1.5 for open 24 hours post-surgery, P<0.001) and morphine consumption (5.6±1.4 mg for MIS *vs.* 17±2.2 mg for open 24 hours post-surgery, P<0.001) than open thymectomy (13). Another study found that patients with MG who underwent MIS thymectomy were less prone to require post-operative mechanical ventilation than patients in the transsternal surgery group (4.2% *vs.* 16.2% respectively, P=0.07) (10). Since MG patients are susceptible to respiratory complications, a minimally invasive thymectomy should be pursued when possible.

Neurologic outcomes of MIS thymectomy remain a subject to debate. Some surgeons reject these newer techniques arguing that surgical resection is more thorough with the open approach and that reliable data regarding remission rates is lacking (6). Bachmann *et al.* carried out a single-center retrospective study that included 106 patients with MG that underwent thymectomy and followed them for a median of 8 years. They reported that MIS patients had a significantly greater improvement in MG-associated symptoms than the open group (100% *vs.* 77.9% respectively, P=0.019), but differences in remission rates were not statically significant (47.6% for MIS *vs.* 35.1% for open, P=0.32) (11). Meyer *et al.* followed 96 MG patients who underwent thymectomy for a median of 6.1 years for the video-assisted thoracic surgery (VATS) group and 4.2 years for the open group. They reported that 34.9% of the VATS group patients went into complete stable remission *vs.* 15.8% in the open group (10). These studies provide evidence that MIS is potentially associated with similar and sometimes even better neurologic outcomes compared to open thymectomy.

In 2020, Imielski *et al.* added that MIS total hospital costs were lower than open approach: $14,504±$10,845 *vs.* $22,847±$20,061 respectively, P<0.001) (5). Although we also found this to be true by quite a large margin, our results were not statistically different owing to the wide variation in cost in the open group.

One of the strengths of our study is that it includes only patients with a primary diagnosis of MG, not thymoma. Including thymoma would have added more patients to our study, but it would have muddied the cohort. Many thymomas, especially large ones, cannot be taken out through minimally invasive means. Thus theoretically, 100% of these MG patients could have had a MIS thymectomy, whereas only 27% actually did. Moreover, this study covers a 6-year period well within the era of MIS for thymectomy. Finally, it is a comprehensive view of thymectomy in all hospitals across Florida.

The limitations of our study are the same as any database study in that granular details such as preoperative MG scores and medical treatment, specific perioperitve complications and pain scores are not available. Also, outcomes after discharge, such as MG symptoms, are not available. As this is a retrospective study, it is subject to selection bias.

Conclusions

Patients who underwent MIS thymectomy for MG had a significantly shorter hospital length of stay and a lower, although not statistically significant, overall cost. After adjusting for age and Elixhauser score, length of stay for the MIS group remained lower compared to the open group.

Since MG patients are susceptible to respiratory complications, an approach to decrease pain and improve post-operative respiratory mechanics is preferred, and therefore a minimally invasive thymectomy should be pursued when possible.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://gs.amegroups.com/article/view/10.21037/gs-22-83/rc

Peer Review File: Available at https://gs.amegroups.com/article/view/10.21037/gs-22-83/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-22-83/coif). IAM reports that he has proctored other surgeons in robotic cases and was paid through Intuitive Surgical. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). No institutional review board for this study was required as the data was collected from an insurance database and all patients were already de-identified.

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