Transcervical Thymectomy for Myasthenia Gravis Achieves Results Comparable to Thymectomy by Sternotomy

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Background. **It remains controversial whether transcervical thymectomy offers results equivalent to thymectomy by way of a median sternotomy in the treatment of myasthenia gravis. Furthermore, preoperative prognostic factors have not been clearly defined.**

Methods. **This study is a retrospective chart review and interview of 78 patients completing transcervical thymectomy for myasthenia gravis between 1992 and 1999.**

Results. **There were 24 men and 54 women. Mean age was 40 years (range, 13 to 78 years). Twelve patients were in Osserman class 1, 25 in class 2, 30 in class 3, and 11 in class 4 (mean, 2.5). There was no perioperative mortality and 6 (7.7%) morbidities. Mean length of stay was 1.5 days and mean follow-up, 54.6 months. The crude cumulative complete remission (asymptomatic off medications for 6 months) rate was 39.7% (n = 31). Only 8 patients (10.3%) failed to improve after transcervical thymectomy. Kaplan-Meier estimates of complete remission were 31% and 43% at 2 and 5 years, respectively. Eight patients with thymoma had a 5-year estimated complete remission rate of 75% in contrast to 43% in 38 patients with thymic hyperplasia and 36% in 32 patients with neither thymoma nor hyperplasia ($p = 0.01$). Twelve patients with ocular myasthenia had a 5-year estimated complete remission rate of 57%, whereas patients with mild-to-moderate (n = 55) or severe (n = 11) generalized symptoms had 5-year complete remission rates of 43% and 30%, respectively ($p = 0.21$).**

Conclusions. **Overall, extended transcervical thymectomy offers results that are comparable to those published for the transsternal procedure. Patients with milder disease (including isolated ocular disease) and taking no preoperative immunosuppressive agents appear to experience higher remission rates. In contrast to previous studies, we also find that small thymomas predict better responses to thymectomy.**

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Thymectomy is an accepted therapy in selected patients with myasthenia gravis (MG). Its salutory effect on the natural history of the disease was first suggested by Blalock and colleagues in 1939 [1]. Transcervical thymectomy (TCT) was first performed in 1912 by Sauerbruch and reported by Schumacher and Roth [2]. Although this was the first approach to thymectomy to be described, it has remained controversial. The benefits of TCT, including decreased morbidity and hospital stay versus transsternal thymectomy, are relatively unquestioned. The procedure has been criticized, however, primarily because many believe that a complete resection cannot be performed by this exposure and that incomplete resection may compromise outcome. Some investigators, in fact, have advocated maximal thymectomy with extensive neck and mediastinal dissection to assure complete resection of all thymic tissue [3].

Inconsistency in terminology, outcome measures, and statistical analysis has made it difficult to compare results across studies addressing the impact of thymectomy on MG, including those studies attempting to compare the results obtained by TCT versus transsternal thymectomy [4]. Most investigators agree that sustained, complete remission (CR) should be the primary outcome measure in these studies. A sustained, CR must be carefully defined as a patient who is asymptomatic without medications for a minimum of 6 months to exclude those patients who recur after initial remission. This definition can be used to calculate the crude cumulative CR rate (simply, the number of patients with CR/total number of patients), which ignores differing durations of patient follow-up postoperatively. Complete remission, however, is a time-dependent outcome, and more remissions are expected with longer follow-up. To account for this time factor and thus allow comparison among studies that report at different follow-up times, the proper statistical analysis method is life-table survival analysis

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Table 1. Modified Osserman Classification

Osserman Score	Description
0	Asymptomatic
1	Ocular signs and symptoms
2	Mild generalized weakness
3	Moderate generalized weakness
4	Severe generalized weakness, respiratory dysfunction, or both

(Kaplan-Meier estimation). Unfortunately, there are very few publications that report data analyzed by this statistical method.

Since 1992 extended transcervical thymectomy as described by Cooper and associates [5] has been our procedure of choice for MG patients without thymoma as well as selected patients with small thymomas [6]. Patients who are unable to completely extend their neck, and those with large thymomas or suspicion of invasive thymomas are operated on through a median sternotomy. We retrospectively reviewed our experience in an effort to determine, in as statistically valid a manner as possible, if the less invasive transcervical approach achieves results equivalent to those published for other approaches to thymectomy.

Patients and Methods

We conducted a retrospective review of 121 consecutive patients who underwent attempted transcervical thymectomy between January 1992 and September 1999. The medical records, operative notes, and pathology reports were reviewed. Of the 98 patients with MG, 92 patients (93.8%) were available for follow-up evaluation by either telephone contact or communication with their neurologist. Eight patients who required extension of the cervical incision were excluded from the analysis (two underwent thoracoscopies and six, median sternotomies), as were 6 patients who had not completed 6 months of follow-up. Thus, 78 patients met criteria for inclusion in the study. The patients' disease was categorized by a modified Osserman classification (Table 1). Because this is the classification that was used in most patients throughout their preoperative care and evaluations, we believe that it was most appropriate to use this classification rather than attempt to retrospectively reclassify patients according to the more detailed Myasthenia Gravis Foundation of America Clinical Classification [7].

The procedure consisted of an extended TCT, as described by Cooper and colleagues [5], involving extracapsular removal of the entire gland including the cervical and mediastinal poles as well as the bulk of the extrathymic mediastinal fat between the phrenic nerves and down to the diaphragm. The procedure does not remove the pleurae or fat directly apposed to the pleurae, tissue posterior to the phrenic nerves, or other areas where ectopic thymic tissue has been described. No drains are left in place.

Crude cumulative CR rate (number of patients asymptomatic off medications for at least 6 months/number of patients evaluated) was calculated. More appropriately, the Kaplan-Meier estimate of time to CR and CR rates at specific time points were also determined. For Kaplan-Meier estimation [8], time to CR was defined as time from operation to first date that CR patients were asymptomatic and off of all medications (start date). These patients then had to remain asymptomatic and off of all medications for at least 6 months follow-up time from the start date to be counted as in CR. Those who had not achieved CR were censored and their time to CR was defined as time from operation to most recent patient contact. These non-CR patients had to have at least 6 months of follow-up after operation to be included in the analysis. Univariate survival analysis using the log rank test [9] was performed to determine the impact of various preoperative and operative factors on time to CR. The Cox proportional hazards regression model [10] was used to determine the simultaneous impact of several prognostic factors. Statistical significance was set at the 0.05 level. All analyses were performed in SPSS statistical package (SPSS Inc., Chicago, IL).

Results

Patient Characteristics

Of the 78 patients with MG, there were 24 men and 54 women, mean age 40 years (range, 13 to 78 years). By the modified Osserman classification, 12 patients had a maximum preoperative severity of illness placing them in class 1, 25 in class 2, 30 in class 3, and 11 in class 4, with a mean preoperative Osserman classification of 2.5 (Table 1). Preoperative treatments are listed in Table 2.

Operative Morbidity

Mean operative time was 96.8 minutes (range, 40 to 180 minutes). There was no perioperative mortality. There was one late death; a 71-year-old man who died 3 years postoperatively due to massive pulmonary embolism. Six patients (7.7%) suffered an operative morbidity: 2 pneumothoraces that required aspiration, 2 wound infections (one of these requiring repeat transcervical exploration for mediastinal drainage), 1 case of atrial fibrillation, and 1 case of vocal cord paralysis. Mean length of stay was 1.5 days (range, 0.5 to 4.0 days). All patients were extubated in the operating room, and none were transfused.

Pathology

The thymus gland was normal in 32 patients and demonstrated follicular hyperplasia in 38. Eight patients had thymoma: 3 in Masaoka stage I, 5 in stage II.

Crude Cumulative Complete Remission Rate

With a mean follow-up of 54.6 months, CR was achieved in 31 patients; the crude cumulative CR rate is thus 31 of 78 patients (39.7%). Fifteen patients (19.2%) were asymptomatic with medications, 22 (28.2%) were symptomatic but improved in Osserman class (all by two classes), 3

Table 2. Preoperative Treatment Regimens

Treatment	Number of Patients
None	1
Single drug treatment (n = 39)	
Pyridostigmine	35
Steroid	3
Azathioprine	1
Two-drug or modality treatment (n = 26)	
P/S	11
P/A	2
P/pheresis	11
A/pheresis	1
P/IVIG	1
Three-drug or modality treatment (n = 8)	
P/S/A	4
P/S/pheresis	2
P/S/IVIG	1
P/A/pheresis	1
Four-drug or modality treatment (n = 4)	
P/S/A/pheresis	2
P/S/A/IVIG	1
P/S/pheresis/IVIG	1

P = pyridostigmine; S = steroid; A = azathioprine; pheresis = plasmapheresis; IVIG = intravenous immunoglobulin.

(3.8%) relapsed after an improvement or CR (1 to less than his original disease severity), and 8 (10.3%) showed no clinical improvement. No patients deteriorated. The crude CR rates were 50.0%, 44.0%, 36.7%, and 27.3% for Osserman classes 1, 2, 3, and 4, respectively.

Kaplan-Meier Estimation of Time to Complete Remission

By Kaplan-Meier analysis method, time to CR was estimated for the 78 patients. The median follow-up for 47 patients yet to obtain a CR was 44 months.

Complete remission rate was 31% and 43% at 2 and 5 years, respectively (Fig 1). According to severity of disease, patients with ocular myasthenia had a 5-year CR rate of 57%, whereas patients with mild-to-moderate or severe symptoms had 5-year CR rates of 43% and 30%, respectively (Fig 2). However, the difference in time to CR among the three groups did not reach statistical significance ($p = 0.21$).

Of factors evaluated by univariate analysis (Table 3), the only ones that predicted time to CR with a $p < 0.05$ was thymic histology and previous azathioprine use. According to histology, the 8 patients with thymoma had a 5-year CR rate of 75%, in contrast to a 43% 5-year CR rate in 38 patients with hyperplasia and 36% 5-year CR rate in 32 patients with no hyperplasia ($p = 0.01$; Fig 3). Excluding the thymoma patients, there was no significant difference in time to CR between those with hyperplasia and those without hyperplasia ($p = 0.10$).

Those without prior azathioprine use had a 5-year CR rate of 48% versus 13% for those with prior azathioprine use ($p = 0.03$). Use of prednisone also showed a trend toward worsened outcome, but this did not reach statistical significance ($p = 0.16$). Patients receiving both pyridostigmine and prednisone ($p = 0.03$) or both pyridostigmine and plasmapheresis ($p = 0.16$) had lower 5-year CR rates than patients receiving pyridostigmine alone.

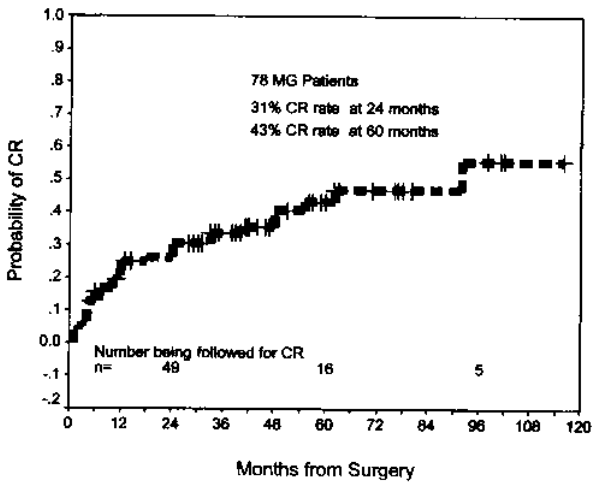

Fig 1. Kaplan-Meier curve for time to complete remission (CR) for all 78 patients. (MG = myasthenia gravis.)

The association between thymic histology (thymoma, hyperplasia, or no hyperplasia) and time to CR was still statistically significant after adjusting for Osserman class (ocular only, mild-to-moderate, or severe) using Cox regression analysis ($p = 0.03$). Additional regression analyses to adjust for prior prednisone or azathioprine use were not performed as it was believed that prior treatment most likely reflected severity of preoperative symptoms, which was already accounted for in Osserman class.

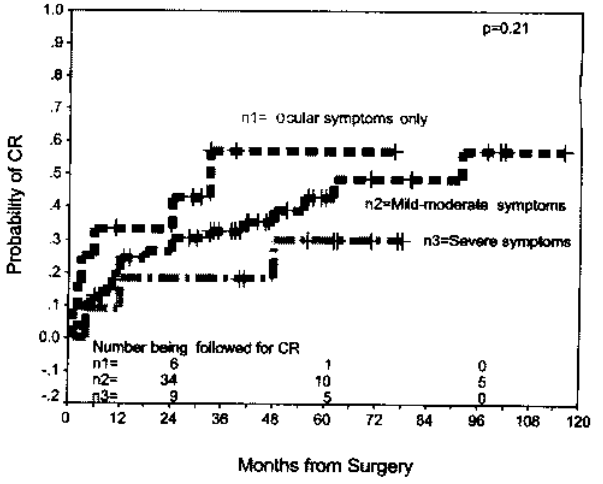

Fig 2. Kaplan-Meier curves for time to complete remission (CR) according to severity of preoperative disease. There is a trend that does not reach statistical significance (p = 0.21) suggesting higher remission rates in earlier stage disease (n = 12, ocular; n = 55, mild/moderate generalized; n = 11, severe generalized).

Table 3. Five-Year Kaplan-Meier Complete Remission Estimates by Preoperative and Operative Factors—Univariate Analysis

Variable	Level	N	Kaplan-Meier Estimates of CR Rate at 5 Years	Log Rank *p* Value
All patients		78	43%	-
Age	<45 yr	53	46%	
	45+ yr	25	36%	0.62
Sex	Male	24	33%	
	Female	54	49%	0.12
Presurgery Osserman class	1, Vision symptoms	12	57%	
	2–3, Mild/moderate symptoms	55	43%	
	4, Severe symptoms	11	30%	0.21
Thymic histology	Thymoma	8	75%	
	Hyperplasia	38	43%	
	No hyperplasia	32	36%	0.01
Symptom duration	<2 yr	53	50%	
	2+ yr	22	28%	0.38
Prior pyridostigmine	No	10	40%	
	Yes	68	43%	0.50
Prior prednisone	No	53	48%	
	Yes	25	33%	0.16
Prior azathioprine	No	67	48%	
	Yes	11	13%	0.03
Prior plasmapheresis	No	68	46%	
	Yes	20	37%	0.43

Comment

Transcervical thymectomy, although it offers advantages in terms of morbidity, patient comfort, and length of stay, has been criticized based on the belief that total thymectomy cannot be performed by this approach and the presumption that therefore, TCT must result in lower rates of MG remission. However, complete resection of all thymic tissue may not be achieved even by the radical approach of "transcervical transsternal maximal thymectomy" advocated by Jaretski and Wolff [3]. When this more radical procedure is performed, complete remission is still obtained in only a subset of patients [11]. The introduction of the Cooper Thymectomy Retractor (Pilling Co., Fort Washington, PA) in 1988 represented a significant improvement for exposure of the anterior mediastinum during TCT [5], and those who have performed the procedure with this device know that extracapsular mediastinal dissection can now be performed transcervically. In this setting, the key question in the surgical management of MG becomes not the radicality of a particular procedure, but the results obtained by that procedure.

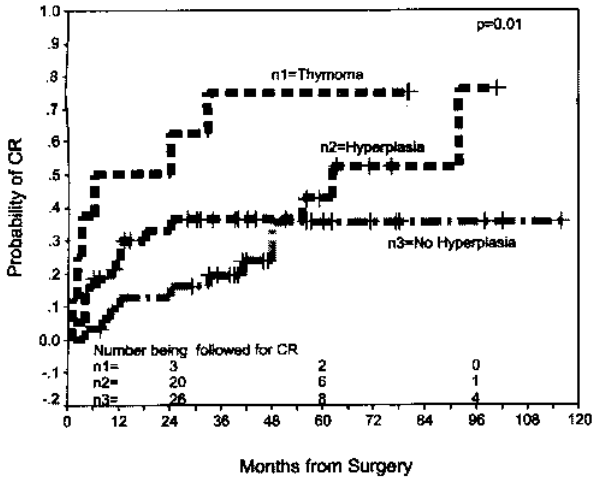

Fig 3. Kaplan-Meier curves showing significant difference (p = 0.01) in complete remission (CR) rates according to thymic histology, with the patients with small thymomas having the best response (n = 8, thymoma; n = 38, hyperplasia; n = 32, no hyperplasia).

There are few published head-to-head comparisons of TCT versus thymectomy by median sternotomy, and those that have been performed are largely irrelevant to the current era as they were carried out well before the introduction of the Cooper retractor and thus report on TCT without the ability to perform an extracapsular dissection (basic TCT) [12, 13]. We are thus left to compare retrospective series that report on results with one or another approach to thymectomy in the era since extended TCT has been possible. Cooper and colleagues, in three reports, have demonstrated excellent results for extended TCT with crude CR rates of 52% at a mean follow-up of 3.6 years [5], 35% at a mean of 5.0 years [14], and 44% at a mean of 8.4 years [15]. The first two reports [5, 14] present data from the same group of patients. This group's work has been criticized primarily because (1) time-corrected complete remission rates have not been calculated, and (2) the series were believed to include a greater percentage of patients with milder disease as compared to series using the sternotomy approach.

Table 4. Published Results of Three Approaches to Thymectomy[a]

	Authors [Ref]	Crude Complete Remission Rate (%)	Mean Follow-up (yr)	Kaplan-Meier 5-Year Remission Rate (%)
Maximal Transcervical/ Transsternal	Ashour et al [36][b]	35	1.7	N/A
	Jaretski et al [11][b]	46	3.4	50
	Budde et al [19]	21	4.3	N/A
	Busch et al [37]	19	7.7	N/A
	Klein et al [38]	40	5.0	N/A
Transsternal	Masaoka et al [23]	40/45	5.0/20.0	N/A
	Mulder et al [39]	36	3.6	N/A
	Stern et al [40]	50	6.8	N/A
Extended Transcervical[c]	Bril et al [15][b]	44	8.4	N/A
	Calhoun et al [14][b]	35	5.0	N/A
	Shrager et al (current study)	40	4.6	43

[a] Includes only studies in the past 20 years in the English language literature, representing a pure series of one type of procedure, in adults, with at least 48 patients, that report complete remission rates as defined herein and mean follow-up. [b] Excludes thymoma cases. [c] Includes only studies representing pure series of extended TCT using the Cooper Thymectomy Retractor.

N/A = not applicable.

In the present study, we address the impact of follow-up time by estimating time to CR using Kaplan-Meier survival analysis. The issue of preoperative severity of disease is a thornier one and may not be resolved without a randomized clinical trial. In the report by Calhoun and co-workers on extended TCT [14], the mean preoperative Osserman class is in fact 3.0, only 0.25 less than the mean Osserman class in the series of maximal thymectomy by Jaretski and associates [11] to which the TCT data are often compared.

In our series, the mean preoperative Osserman class of 2.5 does indicate that the patients had somewhat less severe disease. This is likely a result of the fact that our neurologists have come to refer patients with ocular disease for TCT. It should be emphasized, however, that although we identified a trend toward improved results with lower stage disease, this trend did not reach statistical significance. Furthermore, there are almost as many previous studies suggesting no difference in response to thymectomy according to severity of disease [16–20] as there are those suggesting that patients with less severe disease do respond better.

Table 4 lists selected (see table legend for method of selection), published results for thymectomy by median sternotomy and by extended TCT, including this report. Note that there are little, if any difference, between the reported crude, CR rates regardless of the method of thymectomy: for extended TCT the range is 35% to 40%; for various transsternal techniques it is 19% to 50%; and for the "maximal" transcervical/transsternal approach, it is 35% to 46%. As noted in the table, the only two publications that report Kaplan-Meier estimates of time to CR that met our criteria for evaluability are ours with TCT and the one by Jaretski and colleagues [11] with maximal thymectomy. These 5-year CR rates of 43% and 50%, respectively, also do not differ dramatically.

There are a few other publications [17, 21] that report Kaplan-Meier estimates of time to CR as well as crude CR rates for MG after transsternal thymectomy; ours is the only one reporting Kaplan-Meier estimates after extended TCT. Such "corrected" CR rates allow more appropriate comparison among studies with differing lengths of follow-up. If future researchers would report such rates, the thoracic surgical community would be in a better position to resolve the controversy regarding TCT versus transsternal thymectomy.

Regarding preoperative factors that we found to be associated with improved outcome, the strongest association was with the pathologic findings within the removed thymus. Our finding of a significantly improved response to thymectomy in those with thymoma is quite in contrast with the existing literature, in which the presence of thymoma has generally been considered a negative prognostic factor for remission [11, 17, 22–26]. It should be noted, however, that Papatestas and colleagues [27] have previously reported an association similar to ours between small thymomas removed by TCT and a higher remission rate.

A likely explanation for this finding is that we are reporting on a select group of thymomas. With thymomas that are invasive or more than 3 cm in diameter, we continue to perform a median sternotomy rather than TCT. These patients, therefore, would not have been included in the study population. The thymomas reported herein were all in stage 1 or 2. It is feasible that small or early stage thymomas, such as those in this study, represent a good prognostic indicator for response of MG to thymectomy, whereas larger or stage 3 and 4 thymomas represent a negative prognostic factor.

Our data suggest a trend toward lower Osserman class being predictive of higher CR rate, but this did not reach statistical significance ($p = 0.21$), likely due to the small number of patients in the best and worst symptom classes. In a subsequent exploratory analysis, time to CR was compared between patients with ocular symptoms only and those with any generalized symptoms. This also did not reach statistical significance, but more closely approached it ($p = 0.13$). The only other evaluated vari-

able that even approached statistical significance for association with time to CR was preoperative use of immunosuppressive drugs, which appeared to increase time to CR: prednisone ($p = 0.16$), azathioprine ($p = 0.03$). One interpretation of this finding is that preoperative immunosuppressive drug usage is serving as a surrogate for more severe disease. With this interpretation, these findings taken together lend further support to the already entrenched notion that patients with more severe disease are less likely to achieve a CR. Another possible interpretation, however, is that use of immunosuppressive agents somehow alters the immunologic environment in such a way as to reduce the effectiveness of thymectomy, and that the severity of preoperative disease is not an important prognostic factor.

Traditionally, thymectomy has been indicated in patients with generalized MG, and patients with ocular myasthenia have been referred for surgical intervention only in cases with thymoma. This bias against thymectomy for ocular myasthenia results from several papers indicating poor responses to the operation [28–31]. Schumm [32], Masaoka [23], and Nakamura [33] and their colleagues, and most recently Roberts and associates [34], however, have presented data suggesting that thymectomy is highly effective for ocular MG. In our 12 patients with pure ocular myasthenia, the CR rate was 50% at a mean follow-up of 6 years, and the Kaplan-Meier estimate of CR at 5 years was 57%. These results are comparable to the results achieved by the more extended operation. Furthermore, no patient with ocular myasthenia in either our series or Shumm's, and only one in Roberts', deteriorated or developed generalized disease, whereas this is reported to occur in as many as 50% of unoperated patients [35]. On the basis of this information, we believe, as do other investigators, that early operation in this group should be recommended. This is particularly true when these results can be achieved by the minimally morbid transcervical approach.

It has been sufficiently documented in previous studies of TCT that this approach allows thymectomy to be performed with low morbidity and a dramatically shorter length of stay than the transsternal operation. Our data confirm these findings, with 6 morbidities (7.7%), only 2 of which (2.6%) could be considered major, and a mean length of stay of 1.5 days.

In summary, this study represents the first from a group other than that of the originator of extended TCT [14] to report results comparable to transsternal thymectomy in the management of MG. Furthermore, questions that have been raised by that group's publications due to variations in statistical analysis should be allayed by our reporting of both crude CR rates and CR rates estimated by Kaplan-Meier analysis. In addition to documenting similar results in MG by TCT versus sternotomy, other novel findings of this study are that patients with small thymomas appear to have improved response of MG to thymectomy, and that patients with ocular myasthenia have the best outcome after TCT. There is certainly a learning curve associated with TCT, and although the data presented herein demonstrate what we believe are clear benefits to the patient, these accrue only in the hands of a surgeon who is experienced with the procedure. Until the technique is more widely disseminated in the surgical community, a surgeon with a MG patient before him or her must perform the procedure with which he or she is most comfortable.

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DISCUSSION

DR F. GRIFFITH PEARSON (Mansfield, Ontario, Canada): I would just make a few comments—more historical than current. I was introduced to the technique of transcervical thymectomy by Paul Kirschner, who had worked with Papatestas in New York City, and we began using this technique in Toronto in the late 1960's. Indeed, I introduced Joel Cooper to the transcervical technique when he came up to Toronto in 1972, Dr Cooper had the wisdom to use a suspended, fixed retractor, instead of an exhausted resident, to maintain elevation of the sternum and better display the anterior mediastinum.

I can recall hearing Dr Papatestas in the mid-'70s at a meeting in Chile with his huge experience. He was a surgeon working with Osserman in New York City, and did many hundreds of transcervical thymectomies, including some small thymomas, as you pointed out. You may be one of the few at this meeting who has read his papers. He died many years ago, and nothing further has been written for several decades. He reported very long-term follow-up information, and observed a continuing incidence of remission from myaesthenia even beyond 20 years. You do not have any trouble persuading me at the moment that transcervical thymectomy, with whatever additional technical aids make it easier and more complete, quite reasonable. I agree with you; we do not have any proof that taking out every last iota or speck of thymic tissue adds to this remission rate in a substantial way.

Having seen your graph of an ocular case that went for 5 years without a remission, I know that our neurologist, Dr John Humphreys, who co-authored some the original papers with Cooper, would probably have come to us and said, "You probably didn't get all the thymus in that patient," and ask us to reexplore the patient. We didn't have any sophisticated imaging techniques beyond tomography. We did reexplore a number of cases, particularly young patients with hyperplasia who did not improve within a period of 5 years. In some of these cases, residual thymus was found and removed—with subsequent remission thereafter. I would like to know whether you reexplored any of your cases?

Thank you.

DR SHRAGER: Thank you, Dr Pearson, for the historical perspective.

As far as I'm aware, we have not reexplored anyone, and that may be as much a function of the neurologists' feeling that "you get one shot" as anything else. Obviously, we do have patients who have not had a complete response. If the neurologists took the approach that every patient who did not have a complete response may have residual thymus tissue, then they would likely send at least some of those patients back. Apparently they do not believe that. As far as I am aware, we have not reexplored anyone.

DR THOMAS R. TODD (Abu Dhabi, United Arab Emirates): I'll give you a further historical perspective which will explain my comment. I am the exhausted resident from the Cooper days. The other comment that I want to make is that a further technical modification of what Dr Cooper described has been undertaken by Dr Keshavjee in Toronto. I have watched Dr Keshavjee do it this way, and I must say that I am thoroughly impressed with what it adds to the procedure. Shaf will put the sternal retractor in as you showed in your slide, but then he will use a straight telescope and do it all off the screen, video assisted. It is a fantastic way to teach the procedure, because otherwise it is a hard procedure to teach residents and, in addition, far more precise and faster than doing it just with the

headlights. It is an efficient technical modification to what you have very nicely described.

DR SHRAGER: Thank you. We have placed the scope in a few times to try to show the residents some of the anatomy but not specifially to help in the dissection.

DR MARK D. IANNETTONI (Ann Arbor, MI): Dr Shrager, I have a comment and a question. The advantage to a cervical thymectomy theoretically would be to get the patient home sooner with less morbidity. By adding a partial sternal split, you can get the patient home in 23 hours or less and still get full exposure to the distal thymus and clear out all that fat, and then if we do find a thymoma, we will split the sternum to get all the fat. Is the reason to do this for patient comfort or do you feel you get the same resection with this?

DR SHRAGER: Well, I do not know a hundred percent whether we get the same resection, but I know that we get the same results. So either we get the same resection or it does not matter how much of a resection you get as long as you get the bulk of the thymus gland; and I am not in a position to answer that question. I guess the response would be that if you can get equivalent results without splitting the sternum, then why split the sternum.