chest dependent.[16-18] Nitrous oxide should be discontinued immediately and the lungs ventilated with an FI_{O_2} of 1.0.[19] A catheter should be inserted into the central venous circulation for aspiration of air and infusion of resuscitative drugs. It is important that circulatory and ventilatory support be maintained without interruption, because once in the pulmonary circulation the entrapped air can be excreted only by diffusion through the lungs.[20]

Vigilant post-resuscitative care is essential for a favorable neurologic outcome. Hypotension, hypoxemia, and hypoglycemia should be avoided. Seizure activity is a metabolically expensive event for the postanoxic brain; therefore, it should be suppressed with anticonvulsants. Focal neurologic deficits suggest the presence of a patent foramen ovale, and care should be taken that no further air be entrained through peripheral or central venous access. Finally, repeated neurologic examinations are mandatory for the detection and prompt therapy of potentially fatal cerebral edema.

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Predicting the Need for Postoperative Mechanical Ventilation in Myasthenia Gravis

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Myasthenia gravis causes weakness of voluntary muscles, sometimes including those of respiration, so that patients with this diagnosis may be at increased risk of developing postoperative respiratory failure. Several authors have proposed criteria for predicting which myasthenic patients will require prolonged postoperative mechanical ventilation.[1-3] When Leventhal *et al.* recently described such a preoperative scoring system for myasthenic patients

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TABLE 1. Characteristics and Predictive Scores of Transcervical Thymectomy Patients

Characteristic	Score	Mean ± SD
Total n	92	
Males/females	36/56	
Age range	16–81 yr	44.7 ± 18
Disease duration	3–372 months	38.0 ± 63
Pyridostigmine dose	0–1020 mg/day	290 ± 178
Duration of surgery	50–195 min	87.0 ± 25
n score > 10	23	
Needed ventilation	3 (TP)	
Extubated early	20 (FP)	
n score < 10	69	
Needed ventilation	5 (FN)	
Extubated early	64 (TN)	

n = number of patients; TP = true positive; FP = false positive; TN = true negative; FN = false negative.

undergoing a transsternal thymectomy,[4] they identified four key risk factors. These were: 1) duration of myasthenia gravis greater than 6 yr (12 points); 2) a history of chronic respiratory disease other than respiratory disease directly due to myasthenia gravis (10 points); 3) a dose of pyridostigmine greater than 750 mg per day 48 h before operation (8 points); and 4) a preoperative vital capacity less than 2.9 l (4 points). These risk factors were weighted according to their significance as predictors; a total score of 10 points or greater identified those patients likely to need ventilation for more than 3 h postoperatively.

This model, when applied to the 24 patients in their study,[4] was reported as being correct in 22/24 (91%) of the cases, with no patients being incorrectly predicted to be ready for tracheal extubation (false negatives), and two out of 16 being incorrectly predicted to need ventilation (false positives) when they met the criteria for extubation.

Many centers, including ours in particular, are now using the transcervical approach to thymectomy.[5,6] In this study we sought to determine the value of the Leventhal *et al.*[4] scoring system when it was applied to myasthenic patients who underwent transcervical thymectomy.

MATERIALS AND METHODS

The charts of all myasthenia gravis patients who had undergone transcervical thymectomy in our institution since 1982 were reviewed. Tracheal extubation was performed in the operating room, recovery room, or intensive care unit (ICU) when the inspiratory force was > -20 cmH_2O and the patient appeared to be responsive. The following information was obtained: age; sex; type of anesthetic (inhaled anesthetic used); duration of surgery; duration of ventilation postoperatively; duration of myasthenia gravis; presence or absence of a history of respiratory disease; daily dosage of pyridostigmine; and preoperative vital capacity.

Patient Characteristics. There were 92 patients, all of whom received general anesthesia *via* endotracheal tube. Pyridostigmine was not routinely administered prior to surgery unless the patient required it for respiratory difficulty or was emotionally dependent on it. Anesthesia used was thiamylal, nitrous oxide, oxygen, and a potent inhaled anesthetic (halothane, enflurane, or isoflurane). Muscle relaxants were not used. Postoperatively, all patients were transferred to the recovery room. Once the trachea was extubated and the patients were able to swallow Jello®, they were given their usual oral dose of pyridostigmine. Most were transferred to the ward 90 min later, while a few, who did not meet the criteria for tracheal extubation, were transferred to the surgical ICU for prolonged controlled ventilation.

For each patient the preoperative score was calculated based on those predictors identified by Leventhal *et al.*[4] Information on the first three predictors was available in all of our patients, but vital capacity measurements were only available in the last 30 patients. Where this information was not available, the patient was not assigned any points for this variable in calculating the predictive scores.

Patients predicted as requiring controlled ventilation and who actually required it were labeled true positive (TP); patients predicted as requiring it but actually not requiring it, false positive (FP); predicted as not requiring controlled ventilation but actually requiring it, false negative (FN); and both predicted as and not requiring controlled ventilation, true negative (TN).

The sensitivities (TP/TP + FN), specificities (TN/TN + FP), and predictabilities (TP/TP + FP) of the scoring system, both when applied to Leventhal *et al.*'s[4] transsternal thymectomy patients and to our transcervical thymectomy patients, were determined.[7]

RESULTS

There were 92 patients with a diagnosis of myasthenia gravis, well documented by preoperative electrophysiologic testing, who underwent transcervical thymectomy. Patient characteristics and predictive scores are shown in table 1. Of the 92 patients, only eight (8.7%) required prolonged (>3 h) postoperative mechanical ventilation. Duration of ventilation in this group ranged from 15 h to 3 days (30.6 ± 20 h, mean ± SD).

The sensitivities, specificities, and predictabilities are shown in table 2. The scoring system predicted that 23 of 92 patients would have required prolonged postoperative ventilation. The group of 23 was comprised of 15 patients with a history of myasthenia gravis of greater than 72 months' duration (12 points), yet only two of these needed controlled ventilation; eight patients had a

history of chronic respiratory disease (10 points), yet only one needed controlled ventilation. Two patients were receiving a pyridostigmine dosage greater than 750 mg/day (8 points), one of whom needed controlled ventilation. This patient had no other positive predictors to make the score greater than 10.

TABLE 2. Predictive Scoring System Applied to Transsternal (TST)[4] and Transcervical (TCT) Thymectomy Patients

	TST	TCT
Sensitivity (%)	100	37.5
Specificity (%)	87.5	76.2
Predictability (%)	80	13

DISCUSSION

Following transsternal thymectomy, up to 50% of patients require prolonged postoperative ventilation.[1,8] Previously proposed predictors of postoperative ventilatory requirement include "serious reduction in vital capacity,"[2] presence of bulbar weakness, previous history of respiratory or myasthenic crisis, or a vital capacity of less than 2 l.[3] Leventhal *et al.*[4] retrospectively applied multivariate discriminant analysis to preoperative physical, historical, and laboratory data of 24 myasthenic patients to arrive at their scoring system. When applied to a further 18 patients at their institution, the scoring system was found to be 78% correct.[9]

Grant and Jenkins[10] tested this scoring system retrospectively in 27 patients who underwent thymectomy. Four patients underwent transcervical thymectomy and 23 had partial sternotomy to the third or fourth intercostal spaces. Ten patients received succinylcholine for endotracheal intubation and five received *d*-tubocurarine. Seventeen out of 20 were correctly predicted not to need postoperative ventilatory support, and three were correctly predicted to need ventilation. Four patients, predicted not to need controlled ventilation, needed such ventilation for longer than 18 h; two of these had scores of zero. Of these four patients, only one had received a small total dose (3 mg) of *d*-tubocurarine. (None of Leventhal *et al.*'s[4] patients received muscle relaxants.)

Characteristics of the scoring system as applied to Grant and Jenkins'[10] 27 thymectomy patients result in a sensitivity of 43%, specificity of 85%, and predictability of 50%. These authors did not make any special mention regarding the predictions in their transcervical, as compared with transsternal, thymectomy patients. They concluded that the scoring system was of limited value because it was insensitive to the detection of those patients who needed ventilation postoperatively. The limitations in their particular situation may be associated with the lack of a standardized protocol for managing the thymectomy patients in their series.

Several centers are now using the transcervical approach to thymectomy because it is a less extensive surgical procedure, yet gives therapeutic results reported as being equal to those following the more extensive transsternal approach.[5,6] The surgical approach to the thymus, however, still remains controversial.[11]

In our series of 92 transcervical thymectomy patients, only eight required prolonged postoperative ventilation as compared with the 33–50% reported for transsternal thymectomy.[1,4] This suggests that transcervical thymectomy has a respiratory-sparing effect when compared with transsternal thymectomy. Leventhal *et al.*'s[4] predictive scoring system was not of value when applied to our transcervical thymectomy patients, having a sensitivity of only 37.5% as compared with 100% in their patients or 43% in the mixed series.[10] The poor predictability of the scoring system applied in the transcervical group may be due to differences in stress between the two surgical approaches. Certainly the anesthetic techniques used in our and Leventhal *et al.*'s[4] patients were essentially similar, although the latter authors do not report whether their patients received pyridostigmine preoperatively. That preoperative pyridostigmine may improve respiratory function following thymectomy has been suggested.††

Both Leventhal *et al.*[4] and we used patient responsiveness as a criterion for extubation of the trachea. However, the tracheas of our patients were extubated when negative inspiratory force was > -20 cmH_2O, whereas they used > -25 cmH_2O. In our experience, use of the slightly lower negative inspiratory force has proven reliable in that none of our transcervical thymectomy patients who also met this criterion needed subsequent reintubation and respiratory support. Other than this slight difference, the indications for prolonged ventilation were the same in both studies.

One negative aspect of both our study and the Grant and Jenkins[10] study, both of which seek to test the value of the scoring system, is that they are retrospective and based on chart review. Such studies are prone to several potential problems, including poor control; unnoticed (and therefore unrecorded) differences between the two groups (ventilated and nonventilated); bias in recall and investigator assessment; and missing data. Thus, the chart reviewer may often be required to use considerable judgement in assessing what actually happened to the patient.[12] The advantage of a retrospective study, however, is that it is possible to accumulate a sufficient number of

†† Pandit SK, Kothary S, Orringer M: Preoperative anticholinesterase therapy in myasthenic patients for thymectomy. Paper no. 813. Presented at the Sixth European Congress of Anesthesiology, London, September 1982.

cases to perform a meaningful analysis in a relatively short time. This is of obvious benefit when studying uncommon disorders such as myasthenia gravis. We believe that the potential problems were minimized in our study because most of the patients were anesthetized by the same anesthesiologists (J.B.E., C.T.M.).

Another limitation of this scoring system as it presently exists is that it is based on a small number of patients. Leventhal *et al.* state that the system is not intended to be an absolute rule but that it can help the clinician focus on important patient characteristics, and we certainly agree with this. Further prospective studies of potential risk factors are needed for complete evaluation. Such "outcome" studies may be useful in selecting techniques (both surgical and anesthetic) and perhaps in planning for the health care needs of these patients.

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Total Spinal Anesthesia Following Intercostal Nerve Block

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Intercostal nerve blocks are commonly used for analgesia following thoracotomy. When this block is performed under direct vision *via* an intrathoracic approach by the surgeon, the main problem is the risk of intravascular injection of the local anesthetic. A case of accidental total spinal anesthesia following intercostal nerve block performed by this technique is described. When this complication was previously reported[1,2] the patient had made an uncomplicated recovery; however, the patient in this instance developed neurologic impairment.

Report of a Case

A 59-yr-old woman presented for thoracotomy for a wedge resection of a metastatic tumor in the right lung. Eighteen months previously, she had a left pneumonectomy (for a poorly differentiated squamous cell carcinoma) from which she made an uneventful recovery. She had no clinical cardiovascular disease or abnormal lung function. Her only symptoms were weight loss and backache. Preoperative studies, including bone and liver scans, were normal.

Anesthesia was induced with thiopental and maintained with alcuronium iv, fentanyl iv, 50% oxygen with nitrous oxide, and 0.5% halothane. Pa_{O_2} was 21.4 kPa before the chest was opened and 20.8 kPa during manipulation of the right lung. Arterial blood pressure, measured *via* an intraarterial catheter, varied between 110/70 and 140/85 mmHg with a heart rate varying between 80–95 beats/min. The operation proceeded uneventfully with a measured blood loss of 400 ml. Prior to closing the chest, 20 ml 0.5% bupivacaine with 1:200,000 epinephrine was injected into three intercostal spaces in divided doses under direct vision close to the costotransverse joints. One space was at the level of the operation, one was at the level immediately above, and one was at the level immediately below the incision. No attempt was made to aspirate the syringe prior to injection.

Within 5 min, arterial blood pressure had decreased from 140/85 to 60/35 mmHg and heart rate from 95 to 75 beats/min. Compound sodium lactate solution, 1.0 l, was rapidly infused followed by 400 ml of human plasma protein fraction. Simultaneously, a 15 mg bolus of ephedrine was given iv. The arterial blood pressure promptly rose to 125/75 mmHg. Fifteen minutes later it decreased again and 3 mg ephedrine was injected im. The period of hypotension lasted no more

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