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The effect of muscle-sparing versus standard posterolateral thoracotomy on pulmonary function, muscle strength, and postoperative pain

Increased interest in alternative approaches to thoracotomy has developed because of the considerable morbidity associated with the standard posterolateral technique. We conducted a prospective, randomized, blinded study of 50 consecutive patients to compare postoperative pain, pulmonary function, shoulder strength, and range of shoulder motion between the standard posterolateral and the muscle sparing thoracotomy techniques. Pulmonary function (forced expiratory volume in 1 second and forced vital capacity), shoulder strength, and range of motion were measured preoperatively and at 1 week and 1 month postoperatively. Pain was quantitated by postoperative narcotic requirements, the visual analogue scale, and the McGill pain questionnaire. Morbidity, mortality, and hospital stay were compared between the standard posterolateral and muscle-sparing techniques. There were no differences in postoperative pulmonary function, shoulder range of motion, extent of lung resection, surgical approach time, mortality, or hospital stay. There was significantly less postoperative pain in the muscle-sparing group. The narcotic requirement was less in the first 24 hours ($p = 0.0169$), and visual analogue scale scores were significantly lower ($p < 0.05$) throughout the first postoperative week. Shoulder girdle strength was decreased at 1 week in the standard incision group whereas the strength was preserved with the muscle-sparing approach. Muscle strength had returned to preoperative levels by 1 month in both groups. Morbidity was identical in the two groups with the exception of postoperative seromas. The prevalence of seroma was 23% in the muscle-sparing group and 0% in the standard incision group ($p = 0.0125$). We have demonstrated that the muscle-sparing incision may be a reasonable alternative to the standard posterolateral approach.

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The posterolateral thoracotomy is the standard approach for most pulmonary operations done today. This incision is known for its significant postoperative pain and consequent deleterious effect on pulmonary function. The more recently introduced nonoperative analgesic techniques have been helpful adjuvant measures in controlling postoperative pain.[1,2] Additionally, several surgeons have advocated muscle-sparing thoracotomies as a means of reducing postoperative pain, preserving pulmonary function, and lessening postoperative complications.[3-8] Despite claims of benefit from muscle-sparing procedures, there has been little objective information to support these statements.[9] This prospective randomized study sought to determine the differences in postoperative pain and the changes in pulmonary and shoulder girdle function between the muscle-sparing and the standard posterolateral thoracotomy. The times required for these operative approaches and the development of postoperative complications were also compared.

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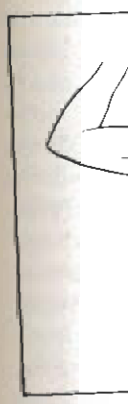

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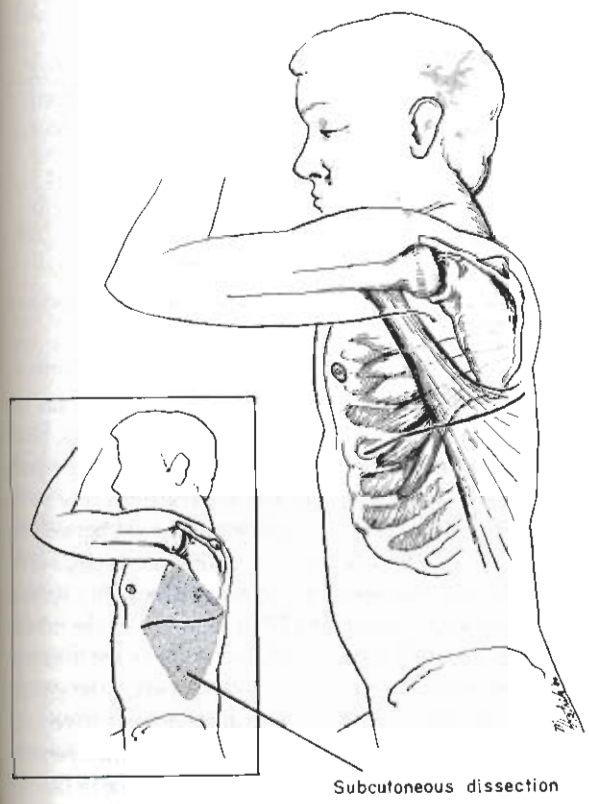

Fig. 1. The *stippled area* of the *inset* represents the generous subcutaneous dissection that allowed adequate mobilization of the latissimus dorsi and serratus anterior musculature.

Patients and methods

After institutional review board approval for the study, subjects were approached for consent to participate. Fifty patients requiring thoracotomy to manage a variety of pulmonary conditions consented to participate and were randomized to undergo either a standard posterolateral thoracotomy or a muscle-sparing thoracotomy. All thoracotomies were performed via the fifth or sixth intercostal space. Patients undergoing thoracic vascular procedures and those having thoracotomy through a lower intercostal space were excluded. Patients with a history of previous thoracotomy were also excluded.

The location and length of the incision used for the muscle-sparing procedure and for the standard posterolateral thoracotomy were similar. For adequate mobilization of the latissimus dorsi and serratus anterior muscles, a generous subcutaneous dissection was performed with the use of the electrocautery. The entire anterior border of the latissimus dorsi was freed from its superior aspect in the axilla toward its inferior insertion at the iliac crest (Fig. 1). After the deep aspect of the latissimus dorsi was freed, the muscle was retracted posteriorly to expose the serratus anterior. The border of the serratus anterior was freed superiorly beyond the tip of the scapula and inferiorly to its attachment on the anterior aspect of the sixth rib. After the intercostal muscles were incised and the chest was entered, two rib retractors were positioned, one to retract the ribs and the other oriented perpendicular to the first retractor to separate the serratus anterior and latissimus dorsi muscles (Fig. 2). During the procedure, care was taken to prevent injury to the long thoracic nerve.

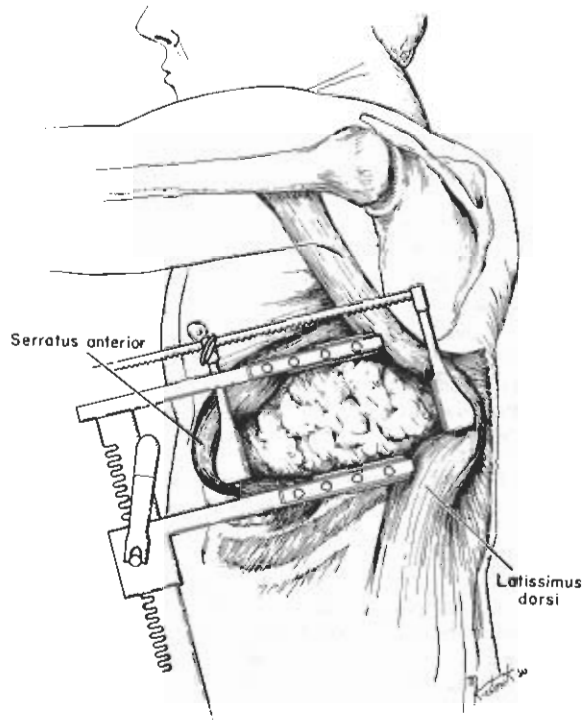

Fig. 2. After the chest had been entered, one rib retractor was positioned to retract the ribs and a second retractor separated the serratus anterior and latissimus dorsi muscles.

A 1 cm segment of the lower rib at the intercostal incision was resected near the junction with the vertebral transverse process. Care was taken to prevent injury to the neurovascular intercostal bundle and to avoid rib fracture while the intercostal space was being spread with the retractor. Rib fracture was recorded if it occurred.

The maximal width of retractor spread was measured in all patients. The time from incision to retractor placement (opening time) and from retractor removal to incision closure (closing time) was also recorded. Double-lumen endotracheal tubes or bronchial blockers were used in most cases. At completion of the pulmonary operation, a single intercostal nerve block of 0.25% bupivacaine (Marcaine) was administered to all patients to anesthetize two nerves above and below the intercostal space.

Pericostal absorbable sutures were used around the ribs, followed by approximation of the intercostal muscles. In the muscle-sparing procedure two soft closed suction drains (Jackson-Pratt; Codman and Shurtleff, Inc., Randolph, Mass.) were placed in the subcutaneous space. These drains were removed on the fourth postoperative day, or later if drainage was greater than 50 ml/day.

The standard posterolateral thoracotomy entailed transection of the entire latissimus dorsi and the lower edge of the serratus anterior. Closure was identical to that in the muscle-sparing group except that the muscles required reapproximation with suture.

Table I. *Patient population*

	MS	*SP*
Age (yr)	58.7	61.2
Sex		
Male	20	21
Female	6	3
Diagnosis		
Primary lung carcinoma	14	16
Metastatic disease	2	2
Benign lesion	4	2
Other	6	4
Procedure		
Wedge	6	6
Lobectomy	15	12
Pneumonectomy	3	3
Other	2	3

MS, Muscle-sparing thoracotomy; SP, standard posterolateral thoracotomy. There is no significant different between the groups.

Preoperative strength and shoulder range of motion were measured by the physical therapy department. These measurements were repeated at 1 week and 1 month postoperatively by the same examiner, who was blinded as to the operative procedure performed. Muscle strength was graded on a scale from 0 to 5, with 0 representing no strength and 5 equaling the normal strength as assessed by the physical therapist.

Pulmonary function tests were measured preoperatively and again at 1 week and 1 month postoperatively. These tests were performed with the patient relaxed and sitting upright. Again, the examiner was blinded as to the operative incision used for each patient.

Postoperative pain was assessed with a visual analogue scale (for pain), the McGill pain questionnaire, and a careful recording of all postoperative narcotic requirements by the patient while in the hospital.[10, 11] The visual analogue scale (for pain) consisted of the patients marking a grade of their pain from 0 mm (absent) to 100 mm (most severe imaginable) on a 100 mm line drawing. The visual analogue scale was explained to the patient preoperatively and administered by the nursing staff every 6 hours for 2 days postoperatively and then every 12 hours for a total of 7 days.

The McGill pain questionnaire is an approach used to compare pain threshold differences between patient age and disease category groups. It was administered at 1 week and 1 month by a psychologist who was also blinded to the operative procedure. This assessment was applied in the study to ensure that there were no obvious psychologic or other chronic pain problem differences between the two thoracotomy groups.

Results

The patient population for the two groups, muscle-sparing and standard posterolateral thoracotomy, are described in Table I. There were no significant differences ($p < 0.05$) between the two surgical groups with respect to age, sex, diagnosis, or the procedure performed. There were two deaths in the series, both in the muscle-sparing group (no significant difference). One patient died of a pulmonary embolus more than 1 month after the thoracotomy and the second patient died of pneumonia and multiorgan failure. The prevalence of atelectasis, bleeding, pneumonia, arrhythmias, and infection were equally distributed between the two incisional groups. The occurrence of postoperative seromas was different between the two incisional approaches. There were no seromas in the standard posterolateral thoracotomy group, but six postoperative wound seromas (23%) occurred in the muscle-sparing group ($p = 0.025$) (Table II). The average postoperative hospital stay was similar between the groups.

Table II. *Complications*

	MS (N = 26)	*SP (N = 24)*	*p Value*
Atelectasis	5	4	NSD
Arrhythmia	3	1	NSD
Bleeding	0	0	NSD
Infection	0	1	NSD
Pneumonia	2	2	NSD
Seroma	6	0	$p = 0.025$
Death	2	0	NSD

MS, Muscle-sparing thoracotomy; SP, standard posterolateral thoracotomy; NSD, no significant difference.

Pulmonary function was measured preoperatively, at 1 week postoperatively, and at 1 month after the operation. The mean values for forced expiratory volume in 1 second and forced vital capacity are shown in Table III. The preoperative pulmonary function values were similar between incision groups. Although these values fell significantly ($p < 0.05$) when measured 7 days after the operation, no difference could be seen in these changes between the two groups. By 1 month pulmonary function returned toward preoperative values in both incisional groups.

Range of shoulder motion was also measured preoperatively and at 1 week and 1 month after the operation. Range of motion was measured in shoulder flexion (0 to 180 degrees), hyperextension (0 to 60 degrees), abduction (0 to 80 degrees), and external and internal rotation (0 to 90 degrees). Mean values for the range of motion on the operative side are shown in Table IV. The range of shoulder flexion and abduction showed significant decreases ($p < 0.05$) at 1 week postoperatively. This decrease in range of motion occurred similarly with both thoracic approaches, and these ranges also returned to preoperative baseline at the 1-month assessment in both groups (flexion, $p = 0.9090$; abduction, $p = 0.9696$).

Shoulder girdle strength was measured by the 0 to 5 scale described earlier. Muscles evaluated included the latissimus dorsi, serratus anterior, pectoralis, shoulder abductors, and internal and external rotators. Interestingly, a difference in muscle strength was noted 1 week after the operation between the thoracotomy groups

Table III. *Pulmonary function tests*

	MS	*SP*
FEV_1 (mean values)		
Preop.	2.14 ± 0.65	2.15 ± 0.89
1 wk	1.43 ± 0.68	1.50 ± 0.59
1 mo	1.87 ± 0.44	1.84 ± 0.80
FVC		
Preop.	3.21 ± 0.97	3.17 ± 1.04
1 wk	2.18 ± 1.05	2.19 ± 0.69
1 mo	2.86 ± 0.66	2.66 ± 0.92

MS, Muscle-sparing thoracotomy; SP, standard posterolateral thoracotomy; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity. There was no significant difference between groups.

Table IV. *Range of motion on operative side*

	MS	*SP*
Flexion (0-180 degrees)		
Preop.	158.0	152.8
1 wk	138.0	139.9
1 mo	156.5	153.6
Abduction (0-180 degrees)		
Preop.	149.3	149.4
1 wk	134.0	136.7
1 mo	155.9	152.8
Hyperextension (0-60 degrees)		
Preop.	61.6	55.7
1 wk	59.6	55.1
1 mo	59.4	59.2
Internal rotation (0-90 degrees)		
Preop.	71.9	78.0
1 wk	76.3	73.5
1 mo	77.7	77.8
External rotation (0-90 degrees)		
Preop.	79.1	78.4
1 wk	78.3	81.2
1 mo	79.8	81.4

MS, Muscle-sparing thoracotomy; SP, standard posterolateral thoracotomy. There was no significant difference between groups.

(Table V). A discernible decrease in strength in both the latissimus dorsi and serratus anterior was noted at 1 week in the standard incision group. The decrease was significant in the serratus anterior ($p = 0.0369$) and approached significance in the latissimus dorsi ($p = 0.0533$). In the muscle-sparing group, shoulder strength appeared to have been preserved in the latissimus dorsi and serratus anterior muscle groups at the 1-week postoperative assessment. It should be noted that shoulder girdle strength returned to preoperative levels of strength by 1 month in both thoracotomy groups.

The total surgical approach time was similar between thoracotomy approaches (MS, 50.1 minutes; SP, 51.5 minutes). Although it took an average of 10 minutes longer to open the chest in the muscle-sparing group (mean times: MS, 30.9 minutes; SP, 20.6 minutes), this time was regained through a quicker closure that did not require suture reapproximation of the thoracic musculature (MS, 19.2 minutes; SP, 30.9 minutes). Incisional spreading width was also similar between groups (mean values: MS, 9.35 cm; SP, 9.32 cm), as was the prevalence of iatrogenic rib fracture.

The mean daily values of the visual analogue scale were always less in the muscle-sparing group, which was considered indicative of less perceived pain with this approach. The mean values for each day are represented graphically in Fig. 3. Visual analogue scale differences were statistically significant between the groups when the total pain within the first 7 days was analyzed ($p < 0.05$). Statistical difference was also noted each day postoperatively with the exception of the first 24 postoperative hours.

Narcotics were given as intravenous morphine in the first 24 hours. Although the visual analogue score was not different during this first day after operation, significantly more morphine was required by the standard posterolateral group ($p = 0.0169$). The average requirement for intravenous or intramuscular narcotics for the standard posterolateral thoracotomy group was 41.8 mg, compared with 28.6 mg for the muscle-sparing group during the first day after operation. This difference in narcotic requirements did not persist after 24 hours in either morphine or oral narcotic use between the thoracotomy groups.

The McGill pain questionnaire data were similar in the two groups, with mean values shown in Table VI.

Discussion

Postthoracotomy pain can be a difficult problem leading to acute pulmonary complications and chronic pain syndromes. Restriction in shoulder function is also a problem appreciated acutely that may become a serious debility for selected patients. Modifying the thoracotomy incisional approach by sparing the thoracic muscles through retraction or splitting techniques has been described by several surgeons.[3, 4, 6, 8, 9, 12-15] Despite claims of reduced morbidity, there has been a paucity of objective data to support or refute the use of these muscle-sparing procedures.[1, 13] This prospective randomized blinded study assessed differences in postoperative pain, shoulder girdle function, and pulmonary reserve between a muscle-sparing procedure and the standard posterolateral thoracotomy.

Thoracic exposure is facilitated with collapse of the lung, and the liberal use of stapling instruments allows safe and precise resection through a less extensive thoracic opening.[12, 16] The mediastinal lymphadenectomy that

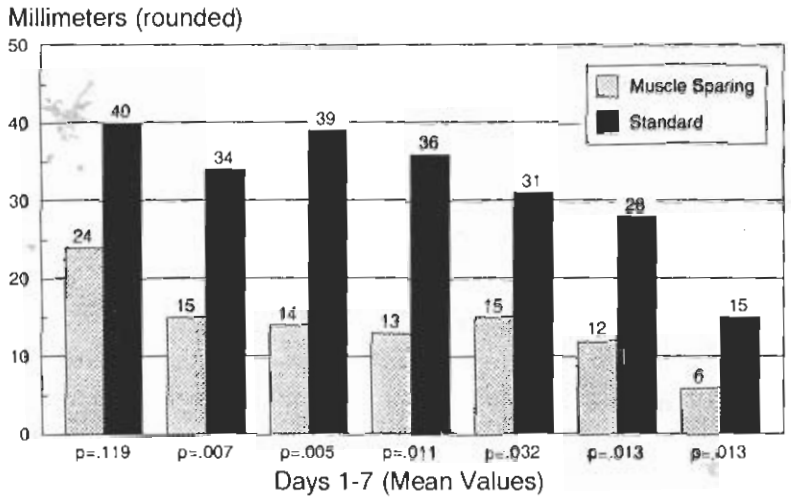

Fig. 3. Visual analogue scale of muscle-sparing versus standard posterolateral incisions. Mean daily values of the visual analogue scale were always less in the muscle-sparing groups, which indicates less perceived pain with the approach.

Table V. *Strength—Operative side*

	MS		*SP*	
Latissimus dorsi (0-5)				
Preop	4.60	($p = 0.515$)	4.45	($p = 0.053$)
1 wk	4.43		4.15	
1 mo	4.78		4.62	
Serratus anterior (0-5)				
Preop	4.70	($p = 0.200$)	4.90	($p = 0.037$)
1 wk	4.61		4.55	
1 mo	4.83		4.93	

MS, Muscle-sparing thoracotomy; SP, standard posterolateral thoracotomy.

Table VI. *McGill pain questionnaire*

	Approach	
	MS	*SP*
Pain now		
1 wk	1.88	1.91
1 mo	1.42	1.48
Pain least (0-5)		
1 wk	1.12	1.13
1 mo	0.74	1.00
Pain worst		
1 wk	3.84	3.65
1 mo	3.16	3.19
Total body score (0-100)		
1 wk	12.12	13.04
1 mo	6.28	7.52

MS, Muscle-sparing thoracotomy; SP, standard posterolateral thoracotomy. There were no significant differences between groups.

accompanied all resections for lung cancer was also readily accomplished through the muscle-sparing incision. The muscle-sparing procedure provided acceptable access to the chest cavity for wedge resections, lobectomies, and pneumonectomies when required. Exposure may be difficult in the muscle-sparing thoracotomy in heavily muscled individuals. However, if at any time further visualization is required for safe completion of the operation, conversion to the standard opening is accomplished by simply incising the thoracic musculature. Additionally, we continue to use the standard posterolateral thoracotomy approach for all thoracic vascular procedures because of the moderately increased exposure available.

The perioperative morbidity witnessed with these two approaches was similar with the exception of postoperative development of wound seroma. Seromas developed in nearly a quarter of the muscle-sparing group despite the use of subcutaneous drains. None of the seromas led to any serious problems and all were easily managed with bedside aspiration before discharge or at subsequent office visits. This rate of seroma development has not been reported by other authors, who have reported that this problem occurs in only 4.7% of patients undergoing muscle-sparing thoracotomy.[1] This difference may be attributed to more extensive mobilization of muscle flaps or simply to a more aggressive policy of aspirating all fluid collection in these patients even when the collections were fairly small. We were impressed with the excellent cosmetic appearance of the thoracotomy wound after muscle-sparing procedures.

We were surprised to see that the total approach time required for the muscle-sparing technique was not signif-

icantly different from that of the standard posterolateral thoracotomy. The time required to mobilize the subcutaneous flaps, the latissimus dorsi, and serratus anterior was made up at closure, because it was not necessary to reapproximate the muscle edges. The thoracotomy width was comparable between approaches, a fact that dispels the possibility of differential spreader traction trauma on the chest cage between incisional approaches as a cause of disparity between groups.

Difference in postoperative pain is a difficult entity to quantify. We believe, however, that the use of the visual analogue scale (for pain) and careful recording of the narcotic requirements for each thoracotomy may be the most objective methods available for us to quantify postoperative pain.[10, 11] The McGill pain questionnaire helped to assure us that the populations of patients studied were similar in their overall perception of pain. The result of the visual analogue assessment and the narcotic requirements certainly trended in favor of the muscle-sparing thoracotomy approach. Although we realize that these data are not unequivocal, they do support earlier claims that this incision is less painful.[13]

Our finding of reduced postoperative pain is in disagreement with Lemmer and associates,[16] who have conducted the only other prospective study evaluating the possible benefit of the muscle-sparing thoracotomy. These authors were unable to find any benefit in pain reduction as measured by the visual analogue scale and morphine requirement during the first 24 after the operation. Our study focused on a broader time frame in the postoperative course of these patients. Variations in the use of postoperative ventilatory assistance and differences in operative anesthetic techniques or frequency of medication distribution by the nursing staff could explain these differences.

Despite this perceived reduction in postoperative pain in the muscle-spared patients, no postoperative difference in pulmonary function as measured by forced expiratory volume in 1 second and forced vital capacity could be found between the two thoracotomy groups. Lemmer and associates[16] conversely demonstrated early improvement (first 24 hours) in pulmonary function as compared with the standard thoracotomy incision. It is possible that there is some short-term functional difference that has diminished by 7 days, when we first reassessed pulmonary function.

Preservation of shoulder girdle strength is significantly better when the muscle-sparing technique is used than when the standard posterolateral approach is used. This benefit was noted at 1 week after the operation but was not significant at the 1-month assessment. Improved muscle function has been suggested by others,[3, 4, 5, 8, 16] but without such substantiating data. Although statistical significance in favor of the muscle-sparing technique was found, the differences were small and of questionable clinical importance for most patients undergoing thoracotomy. There may be some real advantage for patients with previous lower extremity amputation or those with limited lower extremity mobility who depend on their upper extremity musculature more heavily during the early postoperative period.[1]

Conclusion

The muscle-sparing thoracotomy incision provides adequate exposure for most pulmonary procedures. It appears to decrease postoperative pain and reduce shoulder girdle disability in the immediate postoperative period. Its only real disadvantage aside from slightly less exposure is the development of seromas in some patients. We believe that the muscle-sparing procedure is a valuable addition to the armamentarium of the thoracic surgeon. It is a safe and effective approach that may benefit the patient in the early postoperative period.

We wish to express our appreciation to Kelly Hayden and Armine Alioto, RN, for assistance with data collection and JoAnn Boeckman and Wendy Coffey for secretarial support. The assistance with statistical analysis by John Hewett, PhD, and Jane Johnson, BA, is gratefully acknowledged. The illustrative work of Mark Katnik is also appreciated.

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Discussion

Dr. Denis H. Tyras *(New Hyde Park, N.Y.).* We have become very interested in the diverse approach to intrathoracic disease and have become advocates of both the muscle-sparing thoracotomy and the sternotomy for pulmonary disease. Our indications for a preferred thoracotomy rather than a sternotomy are as follows: chest wall involvement, the need for mediastinal dissection, significant cardiac disease not amenable to conventional operative approaches, an anticipated wound-healing problem, ongoing infectious processes, and certainly operations in children.

We prefer the sternotomy approach for patients with upper and middle lobe nodule disease, a need for bilateral exposure, bleb disease, suspected pericardial involvement, and those patients in whom a right or left pneumonectomy is the planned approach.

My associate, Dr. Michael Graver, provided me with his recent operative experience. This represents roughly 80 patients in whom various approaches were used for pulmonary and mediastinal disease within the past 18 months. Half the patients have undergone muscle-sparing thoracotomy, another 25% have had a sternotomy, and only about a quarter of the patients are receiving the standard posterolateral thoracotomy. I might also add that the adjunct of epidural narcotic analgesia after a thoracotomy approach is an excellent means of limiting postoperative pain.

Dr. Landreneau. Allow me to reemphasize that the muscle-sparing technique described allowed adequate exposure for most pulmonary resections for bronchogenic carcinoma.

I would like to reinforce a few points that Dr. Hazelrigg has made. There certainly is adequate exposure for the resection of most bronchogenic carcinomas and the mediastinal lymphadenectomy that is required with this procedure. Secondarily, the sparing of the latissimus dorsi secures an effective means of handling postoperative space and bronchopleural fistula problems through the mobilization of the intact latissimus dorsi muscle flap when needed.

We did not assess differences in early (less than 1 week) postoperative pulmonary function or shoulder girdle strength between incisional approaches in this study. This remains a fertile area of investigation.

Finally, although many variations on the theme of muscle-sparing thoracotomy have been recently described and advocated, there remains little objective evidence of functional benefit with these techniques over standard posterolateral thoracotomy.

Dr. Michael D. Horowitz *(Miami, Fla.).* I agree that there are important reasons to maintain the integrity of the latissimus dorsi and serratus anterior muscles. I have used muscle-sparing thoracotomy in approximately 20 patients over the past 1½ years. My technique is slightly different in that I dissect the auscultatory triangle, retract the latissimus anteriorly, and then enter the chest behind the retracted latissimus. The view one has is similar to that with a standard posterolateral thoracotomy; however, maneuverability within the chest is somewhat less than that with the standard thoracotomy. Nevertheless, exposure has been adequate for the planned operation in every instance, and in no case was it necessary to divide the mobilized muscle.

Like the authors, I have not used this incision for vascular operations or in patients with acute trauma. Despite the fact that I have used this approach in a number of poor-risk patients, there have been no instances of respiratory insufficiency that precluded early extubation.

I would emphasize the fact that aggressive management of pain is important in any patient undergoing a thoracotomy. In addition to intraoperative intercostal nerve blocks, one should consider postoperative pain management with either an intrapleural or epidural catheter, or with a patient-controlled analgesia system.

Dr. Willard A. Fry *(Evanston, Ill.).* There is an alternative to the muscle-sparing thoracotomy described by the authors—the axillary thoracotomy or, as some would call it, the lateral thoracotomy. It, too, involves muscle saving, inasmuch as the only muscle that is actually transected is the serratus anterior. The latissimus dorsi is retracted and the serratus anterior is split in the direction of its fibers. The axillary thoracotomy is the incision we use most often for general thoracic surgical procedures at the Evanston Hospital of Northwestern University Medical School.

We recently reviewed 100 consecutive elective axillary thoracotomies, and the operations performed were those of a standard general thoracic surgical repertoire.* Included among the patients were some high-risk patients with significant underlying cardiopulmonary disease and advanced age. Complications were few, and there were no wound infections. There was also no instance of seroma, because there is no undermining of the skin flaps. The axillary thoracotomy is quicker to make and quicker to close than is the posterolateral thoracotomy.

Some say that this procedure should not be done after an ipsilateral mastectomy, but in our experience a prior mastectomy is not a contraindication to axillary thoracotomy.

We reserve posterolateral thoracotomy for repeat thoracotomy, for major lung procedures with anticipated chest wall resection, for difficult technical operations such as sleeve lobectomies, and for cases in which we expect pleural symphysis, as in a patient with a past history of empyema. Otherwise, the axillary thoracotomy is our incision of choice.

*Fry WA, Kehoe TJ, McGee JP. Axillary thoracotomy. Am Surg (In press).

I would like to know if the authors have used the axillary incision and, if so, what they think of it.

Dr. Hazelrigg. No, we have not used the axillary thoracotomy. I think it does offer most of the advantages of sparing the muscle, and the postoperative advantages should be the same. The prevalence of seroma in our series is bothersome. Seroma was more common than was reported by others who have used a similar incision. The reason for that is unclear, although the extensive mobilization in our operation may be a factor. In addition, in our prospective study we reported everything, even very small collections that might have been omitted from the discussion.

Dr. S. V. Karwande *(Salt Lake City, Utah).* At the University of Utah we have been using a muscle-sparing thoracotomy incision almost exclusively for the past 2 years. Our technique, which has been previously reported, involves dissection through the auscultatory triangle. This dissection is limited basically to the edges of the muscle to minimize postoperative seroma formation. One other advantage of this muscle-sparing incision that was already alluded to by a previous discussant is in the management of postoperative bronchopleural fistulas.

[Slide] This chest radiograph shows a bronchopleural fistula after a pneumonectomy for lung cancer. A muscle-sparing technique had been used at the original operation. We were able to mobilize the entire latissimus and were also able to spare the serratus and the trapezius muscles and use them for the repair. In our experience, the exposure for the posterior mediastinum is excellent through this approach. My question for the authors is this: Have you used this approach for intrathoracic vascular procedures that require access to the anterior mediastinum?

Dr. Hazelrigg. No, we have not used this approach for vascular procedures.

Dr. John H. Lemmer *(Iowa City, Iowa).* There are many testimonials to the virtues of the muscle-sparing thoracotomy incisions published in the thoracic surgery literature. Many surgeons are convinced that such incisions are advantageous. These convictions are based on personal experience, word of mouth, and the common sense idea that limited incisions should hurt less and be less detrimental to pulmonary function, arm mobility, and arm strength. However, there is little objective evidence to date on which to base such conclusions. Dr. Hazelrigg and his colleagues are to be congratulated for their work, which provides objective information from which decisions regarding choice of incision may be made. However, their study revealed no difference in forced expiratory volume in 1 second and forced vital capacity when measured 7 days after the operation.

At the University of Iowa we performed a similar prospective randomized controlled study comparing a limited muscle-sparing thoracotomy incision with standard posterolateral incisions. However, we limited our data collection to the first 24 hours after the operation—the time period we believed to be important in the development of pulmonary-related postoperative complications. We did not remove a segment of rib or administer intercostal nerve blocks. A standardized anesthetic technique, which did not include the use of narcotics after induction, was employed, and the patients were extubated in the operating room at the end of the procedure. To focus our attention on the effects of incision type in postoperative pulmonary function, we omitted patients undergoing pneumonectomy from the study.

Our results demonstrated a significant preservation of forced expiratory volume in 1 second in our group having a limited muscle-sparing incision as compared with the group having a standard posterolateral thoracotomy. Similar results regarding forced vital capacity during the first 24 hours after operation were observed. Interestingly, we demonstrated no significant difference in the forced expiratory flow at 25% to 75%. This test is more effort-independent and is believed to be more sensitive to small-airway abnormalities.

I would propose that the limited incisions may well be advantageous with regard to postthoracotomy pulmonary function and that these advantages are most evident in the very early postoperative period.

Dr. Hazelrigg already answered one of my questions regarding the use of a double-lumen tube and surgical staplers, which we also have found to improve the ease of the operation through limited incisions. My second question is this: Were narcotics administered as a part of the patient's anesthetic program and were all patients extubated in the operating room? Both of these factors might have a significant impact on the early postoperative pain scores and morphine requirements.

Dr. Hazelrigg. Most patients were extubated in the intensive care unit, although some were extubated in the operating room. Many did receive intraoperative narcotics, and that may be part of the reason for the disparity in the first 24 hours, with an inability to show significance with the visual analogue scores in that time period only. In addition, I think the intraoperative administration of 0.25% bupivacaine is an additional factor, so that the first 24 hours is a difficult time to monitor postoperative pain.

Dr. R. J. Cusimano *(Etobicoke, Ontario, Canada).* I realize you had only 35 patients in your study, but do you think it will make a difference with persons with borderline pulmonary function to do a muscle-sparing rather than a standard posterolateral thoracotomy?

Dr. Hazelrigg. That has been our bias, but we cannot affirm it from our data. We did not measure pulmonary function until a week postoperatively. As Dr. Lemmer noted, they at the University of Iowa did measure it in the first 24 hours and did find some benefit using a similar muscle-sparing technique. Our bias is that the answer is *yes*, but from our data we cannot make a statement to that effect.