The Reversibility of Pulmonary Overdistention

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The problems of treatment posed by total pneumonectomy have always been two-fold. First, the creation of a large dead space was contrary to a cardinal principle of surgery. Secondly, the fate of the "good lung" from both the physiological and pathological standpoint, has been the subject of conjecture.

The problem of a large dead space appeared frightening to Graham\(^1\) when he performed his first pneumonectomy. He solved this problem by performing a concomitant thoracoplasty to obliterate it. By so doing, he doubtlessly minimized overdistention of the remaining lung and thus solved the second problem in a satisfactory manner.

Gaensler and Strieder\(^2\) have shown that early thoracoplasty appears more valuable than late thoracoplasty from a function-sparing standpoint but indicate that thoracoplasty per se, even over a dead space, results in some functional loss. Nevertheless, Strieder\(^3\) believes that post pneumonectomy thoracoplasty is a worth-while procedure, if only to prevent annoying cough and make the patient more comfortable.

It is generally agreed upon that prevention of overdistention is desirable. This is so, especially, since the results of treatment, when overdistention has become clinically established, are not satisfactory.

Furthermore, no standardized method of correction of overdistention has been evolved. Various authors have advocated thoracoplasty, pneumothorax, oleothorax, and procedures employing plombage in an effort to allow the mediastinum to stabilize in its normal position in the midline. On the other hand there are surgeons who do not employ post-pneumonectomy space obliterating procedures to preserve function. They believe overdistention is only dangerous in the tuberculous patient where it may result in breakdown of foci in the opposite lung.

It was surprising to us to find\(^4,5\) that few statistics were available to document the clinical improvement often seen following treatment for well established postsurgical compensatory emphysema. The following case histories are presented to substantiate the authors' impression that the often striking amelioration of symptoms following treatment of pulmonary overdistention must have some basis in fact.

Case 1: A 54 year old white male who had undergone right pneumonectomy for bronchogenic carcinoma two years prior to the time he was first seen by us. The operating surgeon had not performed a thoracoplasty because he believed he had not achieved a cure and felt that the patient would not experience incapacitating ventilatory difficulties within his predicted life expectancy. The patient was hospitalized because of extreme shortness of breath on mild exercise. His maximum breathing capacity was 19 liters per minute; his walking ventilation was 16 liters per minute. The mediastinum was retracted entirely within the right chest and there was a severe overdistention of the remaining left lung. Pneumoperitoneum was instituted; the initial amount of air was 2,000 cc's. He received refills at four

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day intervals thereafter for two weeks. He experienced marked symptomatic relief of dyspnea and at the end of this time his maximum breathing capacity was 44 liters per minute and his walking ventilation was 15 liters per minute. The patient did not tolerate pneumoperitoneum well and had much abdominal discomfort with it. He refused to take further treatment.

Comment: The maximum breathing capacity increased 130 per cent after pneumoperitoneum induction. This excellent result obtained despite a well established compensatory emphysema of over two years duration.

Case 2: A 28 year old white male who had undergone right lower lobectomy three years prior to the time we first saw him. Because of postoperative complications with an unexpansible right upper lobe the pneumonectomy was completed approximately one month later. Because of the emotional instability of this patient plus the fact that he had become addicted to drugs, the operating surgeons decided against the performance of a thoracoplasty. Examination revealed that he was extremely short of breath. His mediastinum was retracted into the right hemithorax and there was marked overdistention of the left lung. His maximum breathing capacity was 24 liters per minute and his walking ventilation was 18 liters per minute. It was felt that thoracoplasty would conceivably help but in light of his previous behavior following surgery it was thought hazardous. Pneumoperitoneum was initiated and followed with refills at three day intervals until it became stabilized. At the end of 10 days his maximum breathing capacity was 38 liters per minute and his walking ventilation was 151/4 liters per minute.

Comment: The 58 per cent increase in the maximum breathing capacity was accompanied by a two and one-half liter drop in the walking ventilation indicating increased ventilatory efficiency.

Case 3: A 38 year old white male who was admitted to the hospital with severe hemoptysis. Subsequent workup revealed bronchiectasis of all segments in the left lung and, in addition, there were asthmatic type wheezes present throughout the entire right lung. This patient's maximum breathing capacity was 36 liters per minute and his walking ventilation was 16 liters per minute. It was felt that he should undergo left pneumonectomy but the condition of his other lung posed a serious problem as far as its ability to carry the breathing load was concerned. Differential bronchospirometry showed that 85 per cent of his function was obtained from his right lung and 15 per cent from his left lung. He was given a short course of ACTH which increased his maximum breathing capacity to 46 liters per minute. The asthmatic wheezes were no longer present in the right lung. He underwent left pneumonectomy and 10 days following his maximum breathing capacity was 39 liters per minute. He was advised to have thoracoplasty on his left side but he refused to give permission for this operation. Two months following surgery x-ray films revealed that the mediastinum had shifted considerably to the left side. No asthmatic wheezes were present on the right side but he began to experience shortness of breath on mild exercise. Maximum breathing capacity was 32 liters per minute. He finally gave consent to have thoracoplasty performed and seven ribs were subsequently removed subperiosteally. Six weeks postthoracoplasty his maximum breathing capacity was 44 liters per minute and his walking ventilation was 15 liters per minute and he was able to perform relatively strenuous activity without being short of breath.

Comment: This patient illustrates the often abrupt onset of compensatory emphysema following pneumonectomy. His prompt improvement following thoracoplasty at a relatively early postpneumonectomy date was gratifying.

Case 4: This 42 year old white female had undergone a radical mastectomy on her left side in 1948 for carcinoma of the breast. She was treated with deep x-ray immediately after operative convalescence and has remained essentially well until June 1951, when she developed cough productive of purulent secretions, shortness
of breath, anorexia and weight loss. These symptoms became progressively worse and she was first seen by us in the midle of July 1951. Examination at that time revealed a destroyed left lung and subsequent workup failed to reveal evidence of metastatic disease. It was felt that she suffered severe radiation damage to the left lung and left pneumonectomy was advised. Surgical specimen revealed diffuse interstitial pulmonary fibrosis and fibrous obliterator endarteritis—both consistent with irradiation fibrosis. No attempt was made to obliterate the postpneumonectomy space.

Prior to pneumonectomy the vital capacity was 1.2 liters or 41 per cent of predicted normal. A vital capacity in three seconds was 1.1 liters or 92 per cent of her total vital capacity. Six months postpneumonectomy her vital capacity was 1.3 liters and her three second vital capacity was 1.1 liters indicating no loss of function following the surgical procedure. Despite this finding, she stated that she had become short of breath and x-ray films revealed the trachea to be shifted considerably into the left chest. Dyspnea persisted and she became troubled with chronic, although non productive, cough. These symptoms persisted and it was decided to perform thoracoplasty in an attempt to alleviate dyspnea. This was done in July of 1952, when a limited five rib upper thoracoplasty was performed. She made an uneventful convalescence and stated that her breathing was markedly improved. Ventilatory studies carried out four months postthoracoplasty revealed that her vital capacity was 1.3 liters; that her one-second vital capacity was 0.4 of a liter and that her three-second vital capacity was 1.1 liters. Her maximum breathing capacity was 40 liters per minute and her air velocity index was 0.92. At the time of these studies she was free of cough and had no dyspnea carrying out her normal activities.

**Comment:** No significant change in measureable function occurred at any stage of this patient's course yet dyspnea was no longer a problem following thoracoplasty. Whether the relief of dyspnea was due to the disappearance of cough, or whether another mechanism which procedures dyspnea—immeasurable from a function standpoint—is present, is open to conjecture.

**Case 5:** This 63 year old white male consulted us for extreme shortness of breath. He had been told that he had pulmonary tuberculosis and was retired from his job 10 years ago for this reason. Subsequently he had been treated for "asthma".

X-ray films revealed both upper lobes to be markedly contracted and fibrosed with associated compensatory emphysema of severe degree. The supraclavicular areas were deeply retracted. Fluoroscopy revealed poor diaphragmatic and rib cage motion and laboratory studies showed the presence of acid fast organisms in the sputum.

The vital capacity was 2 liters or 45.5 per cent of the predicted normal. The vital capacity in three seconds was 1.2 liters or 60 per cent of the total. He was short of breath and had great difficulty in walking even a short distance on a flat surface.

Bronchoscopy revealed marked upward retraction of both upper lobe bronchi. The segmental divisions of the left lower lobe could not be visualized due to marked distortion of the bronchial tree secondary to contraction of the left upper lobe.

It was felt that he was not a suitable candidate for definitive treatment of his bilateral upper lobe fibroid tuberculosis and, therefore, pneumoperitoneum was induced solely to alleviate his severe compensatory emphysema.

Following induction of pneumoperitoneum he noted considerable improvement in ability to breathe. He was subsequently discharged to a sanatorium where pneumoperitoneum refills were maintained. Two months following the induction of pneumoperitoneum his vital capacity was 2.5 liters or 58 per cent of predicted normal. His vital capacity in one second was 0.7 of a liter and in three seconds 1.8 liters (72 per cent of total vital capacity).
Comment: This patient has experienced a 25 per cent increase in vital capacity and 50 per cent increase in three second vital capacity, following the alleviation of some of his compensatory emphysema. Although he had no surgery it is felt that the problem of overdistention secondary to shrunken lobes is essentially the same phenomenon noted in postpneumonectomy overdistention.

Discussion

Overdistention of the lung can and does occur whenever there is loss of lung substance following extirpative surgery. It may also occur with loss of lung substance from diseased states. It is a problem more in degree than in kind, and presents symptoms only when the loss of lung substance is relatively large. In the postpneumonectomy state there is often a considerable increase in the lung volume of the remaining lung and this increase is roughly parallel to the increase in the residual air.\(^2\)

There is evidence\(^6\) to show that the development of scoliosis after thoracoplasty results in a marked decrease in ventilatory function. On the other hand, maintenance of pneumothorax in the postpneumonectomy space entirely prevents overdistention and conversion of pneumothorax to oleothorax apparently causes no alteration of pulmonary function or lung volume.\(^2\)

Pneumoperitoneum has not been extensively studied as a therapeutic means of combating postsurgical overdistention, but it would appear to be a valuable adjunct to the treatment of this condition. Its chief disadvantages are that it requires long term maintenance and is poorly tolerated by some individuals. Pneumothorax also shares the disadvantage that it has to be continuously maintained.

Thoracoplasty appears to us to be the most attractive therapeutic device because it does not have to be maintained and because it does not involve the use of foreign bodies, e.g. air, oil, or plastic prosthesis—all of which carry potential hazards. The use of modified thoracoplasty in which the first rib and the transverse processes are left intact minimizes the amount of scoliosis which is in part, at least, responsible for decreased ventilatory function.

SUMMARY

1) Pulmonary overdistention is not always an irreversible process. Therapeutic response may be obtained even when overdistention has been established over relatively long periods of time.

2) The clinical improvement in patients who have overdistention has been documented by improvement in ventilatory function studies in four patients.

3) Clinical improvement in one patient which was not evident by improvement in ventilatory function studies suggests that occasionally there are other, immeasurable, factors to be dealt with.

4) The prevention of overdistention is to be preferred rather than treating overdistention once it has developed.

5) Modified space obliterating thoracoplasty appears to be the most effective and desirable procedure to prevent overdistention.
6) The efficacy of pneumoperitoneum has been demonstrated and, we believe, that it has a therapeutic place in our armamentarium.

RESUMEN

1) La sobredistensión pulmonar no es siempre un proceso irreversible. Puede obtenerse una respuesta terapéutica aún cuando la sobredistensión se ha establecido por períodos relativamente largos.

2) La mejora clínica de los enfermos con sobredistensión, se ha hecho evidente por estudios de la función ventilatoria en cuatro enfermos.

3) La mejora clínica en un enfermo en el que no pudo ponerse en evidencia mejora de la función ventilatoria, sugiere que en algunos casos hay otros factores, no estimables, que intervienen.

4) La prevención de la sobredistensión, es de preferirse al tratamiento de ella una vez instalada.

5) La toracoplastia, obliterations el espacio, parece ser el medio más apropiado y deseable para evitar la sobredistensión.

6) Se ha demostrado la eficacia del neumoperitoneo y, creemos, que tiene un lugar terapéutico entre los recursos útiles.

RESUME

1) L'hyperexpansion pulmonaire n'est pas toujours un processus irréversible. On peut obtenir des succès thérapeutique même quand l'hyperexpansion existe depuis une période relativement longue.

2) L'amélioration clinique chez les malades atteints d'hyperexpansion pulmonaire a été confirmée par les progrès de la fonction respiratoire qui a pu être étudiée chez quatre malades.

3) L'existence de progrès cliniques chez un malade pour lequel la fonction ventilatoire n'avait pas semblé améliorée, fait entrevoir qu'il faut compter avec des facteurs impossibles à mesurer.

4) Il vaut mieux prévenir l'hyperexpansion que de traiter lorsqu'elle se développe.

5) La thoracoplastie semble être le procédé le plus efficace et le plus souhaitable pour éviter l'hyperexpansion. Grâce à elle, on obtient l'oblitération de la cavité dans laquelle le poumon à tendance à se développer anormalement.

6) On a démontré l'efficacité du pneumopéritoine, et les auteurs lui attribuent une certaine place dans l'armement thérapeutique.

REFERENCES

4 Mitchell, Roger S.: Personal communication.
5 Wright, G. W.: Personal communication.