

VENTILATORY FUNCTION STUDIES IN EXTRAPERIOSTEAL PLOMBAGE

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Classical thoracoplasty, being the recognized standard procedure for permanent collapse therapy in pulmonary tuberculosis, has yet to be surpassed by any other surgical method with regard to long-term arrest of the disease and sputum conversion. However, it is a multiple-stage procedure, requiring extensive decostaliation followed by permanent deformity and considerable impairment of ventilatory function (Kaltreider, Fray, and Phillips, 1938; Birath, 1944; Powers and Himmelstein, 1951).

Extraperiosteal plombage procedures using lucite spheres (Wilson, 1946; Woods, Walker, and Schmidt, 1950; Woods and Buente, 1953) and polyethylene sponge (Engberg and Hansen, 1953) have been employed during recent years with very satisfactory results and appear to be relatively simple and safe substitutes for the classical multiple-stage thoracoplasty (Alexander, 1937). In addition, extraperiosteal plombage, by virtue of its negligible operative risk and low morbidity, can be applied to advanced bilateral cases where conventional thoracoplasty would involve too great a risk. In this procedure the requisite collapse is effected in a single stage with no paradoxical motion of the chest wall, and if the plombage material is not removed in a second stage no deformity whatsoever ensues.

Reports on pulmonary function studies in patients undergoing extraperiosteal plombage are few. The loss of ventilatory function appears to be much lower than after classical thoracoplasty (Watson and Gaensler, 1952). We therefore report the results of ventilatory function studies performed in 17 patients before and after extraperiosteal plombage. The post-operative tests were performed between two and six months after operation.

The 17 patients, whose clinical data are listed in Table I, represent only those plombage cases in which accurate ventilatory function tests could be obtained before and after operation. More detailed information and follow-up reports on our

entire series of plombage thoracoplasties will be given in a separate article. In 11 patients, lucite spheres were used as plombage material. In eight of them, the plombe was removed in a second stage approximately three months after its insertion, together with resection of the deperiostealized rib segments. In three patients (Nos. 9, 10, 11) the lucite spheres were left as a permanent plombe. In the remaining six patients polyethylene sponges ("polystan") were used as a permanent plombe, and in three of them (Nos. 14, 15, 16) bilateral plombage was done.

METHODS

Ventilatory function tests were performed according to the method of Baldwin, Cournand, and Richards (1948) with a 9-litre Collins spirometer. The patient was in the supine position, breathing through a mouth-piece into a tank filled with oxygen and room air. After several ordinary breathings vital capacity was obtained by recording the amplitude of a forceful expiration following maximal inspiration. The maximum breathing capacity was recorded by urging the patient to breathe as rapidly and deeply as possible for 15 seconds. The values were calculated in litres per minute. The predicted amounts of vital capacity and maximum breathing capacity as well as the breathing reserve ratios were estimated according to the formulae of Baldwin and others (1948). The air velocity index was determined according to Gaensler (1950).

RESULTS

The pre-operative vital capacities varied between 30 and 84% of the predicted, the average being 67%. The pre-operative maximum breathing capacities values were between 23 and 83%, the average being 50%. The ventilation calculated in litres per minute showed pre-operative values ranging from 2.7 to 16 l./m. Eight patients showed definitely increased values indicating hyperventilation. The breathing reserve ratio ranged between 68 and 95%, the average being 84.6%, a definitely sub-normal value (Cournand cited by Hochberg, 1952). The air velocity index ranged from 0.4 to 1.3%.

TABLE I
PRE- AND POST-OPERATIVE PULMONARY FUNCTION TESTS IN 17 CASES OF EXTRAPERIOSTEAL PLOMBAGE

No.	Patient	Age	Sex	Pulmonary Tuberculosis	Extrapariosteal Plombage	Clinical Result	Pulmonary Function Tests					Change (%)	
							Vital Capacity (% of Predicted Values)	Maximum Breathing Capacity (% of Predicted values)	Ventilatory Capacity (l./m.)	Breathing Reserve Ratio	Air Velocity Index	Vital Capacity	Maximum Breathing Capacity
1	A. S.	19	M	Bilateral, advanced, cavities R.U.L. superior segment R.L.L.	Right, 6 ribs, lucite balls, 2 stages	Cavities closed, sputum negative, discharged	Before op. 82 After 2nd stage 73	46 79	7.5 4.1	87 92	0.5 1.08	-9	+33
2	I. H.	30	M	Bilateral, advanced, cavity L.U.L.	Left, 5 ribs, lucite balls, 2 stages	Cavity closed, sputum negative, discharged	Before op. 78 After 2nd stage 63	47 71	5.61 3.93	95 92	0.6 1.13	-15	+24
3	S. K.	39	M	Bilateral, far advanced, cavities L.U.L.	Left, 5 ribs, lucite balls, 2 stages	Cavities closed, sputum negative, discharged	Before op. 77 After 2nd stage 79	40 57	6.4 5.72	85 91	0.52 0.72	+2	+17
4	J. B.	46	M	Bilateral, far advanced, cavities R.U.L.	Right, 6 ribs, lucite balls, 2 stages	Cavities closed, sputum negative, discharged	Before op. 84 After 2nd stage 82	83 78	10 4.28	88 91	0.98 0.95	-2	-5
5	H. K.	22	M	Bilateral, advanced, cavities R.U.L.	Right, 5 ribs, lucite balls, 2 stages	Cavities closed, spread R.L.L., sputum positive	Before op. 68 After 1st stage 61 After 2nd stage 49	39 34 35	3.93 5.176 4.486	87 89 89	0.57 0.56 0.72	-19	-4
6	M. S.	20	M	Bilateral, advanced, cavities L.U.L.	Left, 6 ribs, lucite balls, 2 stages	Cavities closed, sputum negative, discharged	Before op. 65 After 2nd stage 62	76 50	3.76 4.21	93 90	1.12 0.81	-3	-26
7	Y. H.	47	M	Bilateral, far advanced, cavities R.U.L.	Right, 6 ribs, lucite balls, 2 stages	Apical rest cavity, sputum positive (culture)	Before op. 74 After 2nd stage 72	46 57	10.2 4.83	80 92	0.62 0.79	-2	+11
8	M. S.	22	M	Bilateral, advanced tension cavity, R.U.L.	Right, 5 ribs, lucite balls, 2 stages. R.U. lobectomy	Rest cavity R.U.L., sputum positive (culture) Sputum negative, discharged	Before op. 60 After 2nd stage 68 After lobectomy 66	59 77 86	9 3.30 7.55	88 90 88	1 1.13 1.3	+8	+18
9	I. N.	33	M	Bilateral, advanced, cavities R.U.L.	Right, 6 ribs, lucite balls, 1 stage	Cavities closed, sputum negative, discharged	Before op. 76 After op. 67	74 78	3.3 3.9	93 93	0.95 1.16	-9	+4
10	E. G.	27	M	Bilateral, advanced, cavities L.U.L.	Left, 6 ribs, lucite balls, 1 stage	Cavities closed, sputum negative, discharged	Before op. 69 After op. 58	39 43	5.52 4.14	88 92	0.57 0.74	-11	+4
11	B. R.	30	F	Bilateral, far advanced, cavities L.U.L.	Left, 5 ribs, lucite balls, 1 stage	Cavities closed, sputum negative, discharged	Before op. 80 After op. 93	70 96	5.58 6.21	90 92	0.87 1.03	+13	+26
12	S. G.	35	F	Bilateral, far advanced, cavities R.U.L. and R.L.L.	Right, 7 ribs, "polystan," 1 stage	Cavities closed, sputum negative, discharged	Before op. 30 After op. 32	28 25	7 3.28	74 76	0.93 0.78	+2	-3
13	K. F.	34	M	Bilateral, advanced, cavities L.U.L.	Left, 6 ribs, "polystan," 1 stage	Cavities closed, sputum negative, discharged	Before op. 52 After op. 44	23 23	7.59 4.83	72 83	0.44 0.52	-8	0
14	M. R.	28	F	Bilateral, far advanced, cavities L.U.L. and R.U.L.	Left, 6 ribs, "polystan," 1 stage Right, 5 ribs, "polystan," 1 stage	Cavities closed, sputum positive Cavities closed, sputum negative, discharged	Before 1st op. 61 After 1st op. 61 After 2nd op. 52	25 39 30	2.68 5.17 4.30	81 86 85	0.40 0.64 0.57	0 -9	+14 +5
15	I. B.	52	M	Bilateral, far advanced, cavities L.U.L. and R.U.L.	Left, 5 ribs, "polystan," 1 stage Right, 5 ribs, "polystan," 1 stage	Cavities closed, sputum positive Cavities closed, sputum negative	Before op. 69 After 1st op. 65 After 2nd op. 62	37 36 33	4.8 4.40 9.16	78 80 74	0.54 0.55 0.54	-4 -7	-1 -4
16	R. L.	32	F	Bilateral, far advanced, cavities L.U.L. and R.U.L.	Left, 6 ribs, "polystan," 1 stage Right, 5 ribs, "polystan," 1 stage	Cavities closed, sputum positive Cavities closed, sputum negative	Before op. 68 After 1st op. 54 After 2nd op. 57	59 41 53	3.22 3.92 5.17	91 82 89	0.87 0.76 0.93	-14 -11	-18 -6
17	M. S.	24	F	Bilateral, far advanced, cavities L.U.L.	Left, 6 ribs, "polystan," 1 stage	Rest cavity L.U.L., sputum positive	Before op. 45.5 After op. 47	60 68	16 7.24	68 83	1.3 1.45	+2.5	+8

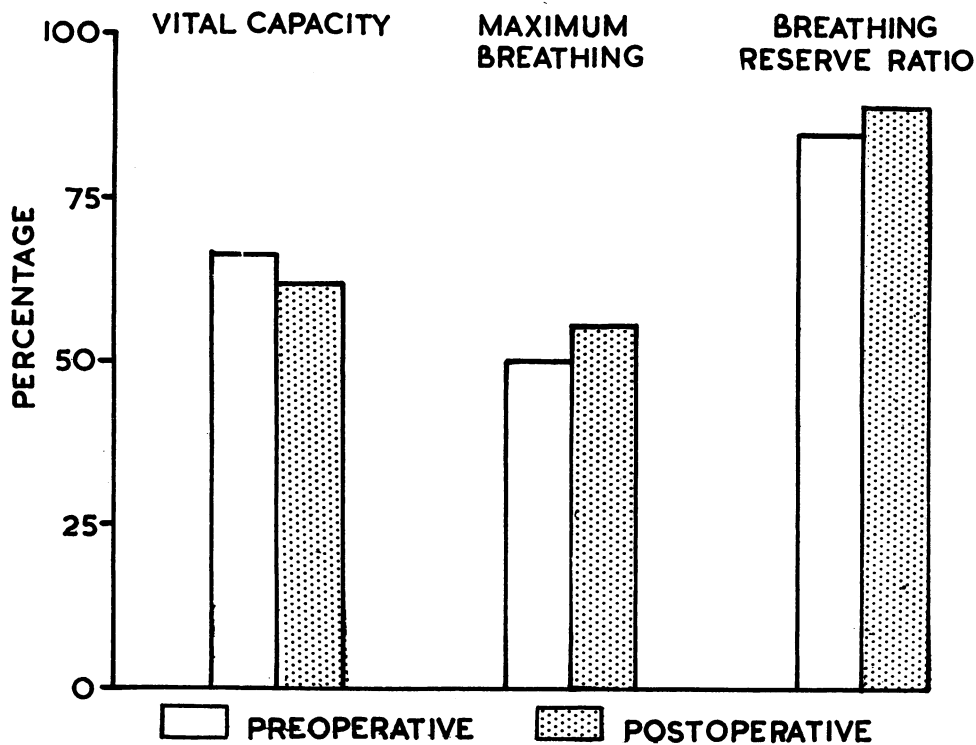


FIG. 1.—Average of vital capacity, maximum breathing capacity, and breathing reserve ratio in 17 patients before and after extraperiosteal plombage.

This shows that pulmonary function in all 17 patients was markedly impaired before the plombage procedure was undertaken.

The post-operative change of vital capacity ranged from -19 to $+13\%$, the average being a loss of 4.7% . The post-operative changes in maximum breathing capacity varied between -18 and $+33\%$, the average being an increase of 6% . The post-operative ventilation showed a tendency to decrease, i.e., a return towards normal values. The post-operative breathing reserve ratio showed an average of 87.9% , indicating a slight improvement compared with the pre-operative level. The post-operative air velocity index showed a tendency to become normal in 11 cases, remained unchanged in two cases, and a further deviation was observed in four.

Fig. 1 is a diagrammatic comparison of pre- and post-operative average values of vital capacity, maximum breathing capacity, and breathing reserve ratio.

COMMENT

The results of our examinations show that following extraperiosteal plombage only a slight

decrease of vital capacity occurred, whereas maximum breathing capacity even improved. Pathological hyperventilation tended to return towards normal in the majority of cases. The breathing reserve ratio showed a slight improvement and the air velocity index approached a more normal value (1.0) after operation.

The insignificant reduction of vital capacity after extraperiosteal plombage indicates that this procedure, by avoiding undesirable over-collapse, does not encroach on relatively normal pulmonary tissue. The slight improvement of maximum breathing capacity post-operatively tends to show that elasticity and distensibility of sound lung parenchyma are not interfered with by this procedure.

Watson and Gaensler (1952) found after extraperiosteal plombage an average vital capacity loss of 17% and an average maximum breathing capacity loss of 6% . Comparing the pre-operative vital capacity and maximum breathing capacity values of their patients with those of ours, it is evident that pre-operative ventilatory function was more severely impaired in our patients. The average vital capacity loss of 4.72% and the aver-

age increase of 6% in maximum breathing capacity observed post-operatively in our patients compare favourably with Watson and Gaensler's results.

The effect of classical thoracoplasty on ventilatory function has been studied by many workers (Alexander, 1936, cited by Donaldson, 1947; Cournand and Richards, cited by Hochberg, 1952; Lambert, Berry, Cournand, and Richards, 1938; Leiner, 1946; Cournand and Richards, 1941), who report a vital capacity reduction varying between 20 and 50% and maximum breathing capacity reduction of 14 to 20%. This is in consonance with our own observations in the two-stage seventh-rib thoracoplasty where average vital capacity losses of 20% and average maximum breathing capacity losses of 19% were found.

The considerable loss of function following classical thoracoplasty appears to be due to deformation of the chest wall by decostaliation, particularly of anterior rib segments, rotoscoliosis, as well as undesirable collapse of sound lung tissue. Most of these shortcomings are avoided in extraperiosteal plombage by which little or no chest wall deformity or scoliosis are produced and where immediate and selective collapse is obtained in a one-stage operation. In our patient extraperiosteal plombage was resorted to, as this appeared to be the only permanent collapse procedure they could withstand without undue operative risk and avoiding additional severe impairment of ventilatory function.

SUMMARY

Pre- and post-operative ventilatory function tests were performed in 17 patients undergoing extraperiosteal plombage.

All patients had a significantly reduced ventilatory function before operation. Post-operatively, vital capacity decreased slightly, whereas maximum breathing capacity, ventilation, and breathing reserve ratio improved.

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