the acid-base equilibrium and in the bacterial flora of the contents of the stomach and small intestine.

5706

Changes in Respirations Produced by Surgical Operations.

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Reduction of vital capacity and elevation and decreased excursions of the diaphragm are significant alterations of the respiratory function known to follow certain surgical operations, notably those on the abdomen. The hypoventilation[1] resulting from the postoperative embarrassment of respiration has been regarded as a factor leading to the development of atelectasis and pneumonia.

To obtain data regarding changes of the separate components of respiration, pneumograph tracings were made before and after operation on a series of hospital patients. The method employed was a modification of that described by Greisheimer[2] in which rubber bags (from sphygmomanometers) were fitted into covers of sufficient length to encircle the body of the patient. One tube was attached to a bulb for the inflation of the bag; the other tube was connected by pressure tubing to a water manometer. One bag was placed about the thorax as high as possible, another around the abdomen below the costal margins. In this manner thoracic (intercostal) and abdominal (diaphragmatic) respirations were recorded synchronously on a smoked surface. In order to make conditions of the experiment uniform, all tracings were taken with the patient in the supine position and with such a pressure in the inflated bag that at expiration the pointer was 2 cm. above the base line. Observations were made on 58 patients, having operations in various anatomical regions as follows: upper abdomen, 19; lower abdomen, 21; thyroid, 9; thorax 5 (4 thoracoplasties); perineum or extremities, 4. The observations reported here are based on more than 200 tracings.

Results. In the following tables, the maximum, minimum, mean and median changes in rate of respiration and depth of thoracic and

[1] Müller, G. P., Overholt, R. H., Pendergrass, E. P., *Arch. Surg.*, 1929, **19**, 1322.

[2] Greisheimer, E., *Minn. Med.*, 1925, **8**, 387.

abdominal breathing are recorded in terms of per cent of the original pre-operative figures. In indicating postoperative days, the day of operation is referred to as the first day. The number of readings on which the percentages are based are indicated for each day in the tables.

TABLE I. *Upper Abdominal Operations.* (19)

				Rate of Respiration					
Days	1	2	3	4	5	6	7	8-10	11+
No. Readings	10	8	5	5	8	3	4	7	8
	%	%	%	%	%	%	%	%	%
Maximum	206	193	158	213	207	140	147	177	129
Minimum	103	85	118	105	105	96	109	100	95
Mean	134	129	134	132	139	112	124	132	112
Median	129	134	128	109	142	100	121	126	114
				Thoracic Excursion					
Days	1	2	3	4	5	6	7	8-10	11+
No. Readings	10	8	5	5	8	3	4	7	8
	%	%	%	%	%	%	%	%	%
Maximum	650	700	333	200	166	183	157	146	133
Minimum	44	122	80	40	60	100	80	77	47
Mean	162	223	147	114	107	154	113	112	82
Median	97	160	106	106	103	181	109	120	83
				Abdominal Excursion					
Days	1	2	3	4	5	6	7	8-10	11+
No. Readings	10	7	5	5	7	3	4	7	8
	%	%	%	%	%	%	%	%	%
Maximum	82	50	75	100	58	150	333	77	100
Minimum	0	1	20	14	16	42	44	42	42
Mean	29	23	47	59	35	78	133	57	77
Median	33	22	50	66	30	42	78	55	77

TABLE II. *Lower Abdominal Operations.* (21)

				Rate of Respiration				
Days	1	2	3	4	5	6	7	8+
No. Readings	9	14	3	5	4	4	4	16
	%	%	%	%	%	%	%	%
Maximum	211	164	136	148	121	140	130	166
Minimum	95	58	71	100	95	105	90	60
Mean	133	126	101	122	114	123	105	120
Median	118	130	95	120	120	123	100	113
				Thoracic Excursion				
Days	1	2	3	4	5	6	7	8+
No. Readings	9	14	3	5	4	4	4	16
	%	%	%	%	%	%	%	%
Maximum	175	350	154	400	140	183	233	270
Minimum	77	30	39	40	64	40	53	35
Mean	122	157	88	187	102	119	141	114
Median	133	163	72	170	104	126	139	96
				Abdominal Excursion				
Days	1	2	3	4	5	6	7	8+
No. Readings	9	13	3	5	4	4	4	16
	%	%	%	%	%	%	%	%
Maximum	225	125	50	133	175	116	133	209
Minimum	0	0	0	10	0	80	0	0
Mean	65	53	21	67	58	101	82	114
Median	45	50	15	63	29	104	98	119

The tables show that an increased rate of breathing occurs following abdominal operations. The average depth of thoracic breathing increases and that of abdominal breathing decreases during the first few days after both upper and lower abdominal operations. It will be observed, however, that in the case of upper abdominal operations, the reduction in abdominal excursion is greater than in the case of lower abdominal procedures.

The observations in other anatomical regions are probably too few for definite conclusions but it is noteworthy that no apparent reduction of the amplitude of abdominal excursions occurs. Following thyroidectomies there was some decrease in depth of thoracic breathing without significant alteration of the abdominal excursions. Following thoracic operations, there was evidently an increased abdominal breathing with a variable effect on thoracic breathing. Following operations on the extremities or perineum, significant changes did not occur.

The increased rate of respiration following abdominal operations is probably due chiefly to the reduction of vital capacity but other factors such as fever, pain, and anxiety, may also accelerate the rate. The decrease in respiratory rate occurring in some instances may be the result of the administration of morphine.

There are a number of factors believed to contribute to the decrease of diaphragmatic breathing, such as pain, reflex splinting of the diaphragm and abdominal muscles, alterations of intra-abdominal pressure, abdominal distention and the effect of sedatives. Experiments being carried on indicate that the greatest inhibition of abdominal breathing occurs after the effects of the anesthetic (spinal) have disappeared, *i. e.*, when the patient is having pain. This observation suggests that voluntary or involuntary splinting of the diaphragm and abdominal muscles is most important of the several factors leading to decreased diaphragmatic breathing.

An increase in the amplitude of intercostal breathing often occurs and apparently serves to compensate for the decreased function of the diaphragm.

This study by means of respiration tracings has been supplemented by a series of vital capacity studies. A measure of the patient's ability to blow up a column of water in a glass tube was also made. Both of these functions are greatly diminished postoperatively and will be discussed more fully at a later date.

Conclusions. These observations provide additional evidence that there is a post-operative embarrassment of respiration follow-

ing abdominal operations and that it is the diaphragmatic component that is primarily affected.

Inasmuch as post-operative pulmonary complications usually occur in the lower lobes and most commonly follow operations on the abdomen, it is probably more than a coincidence that abdominal operations result in decreased diaphragmatic excursions with the attendant diminution of ventilation of the lower lobes of the lungs.

5707

Fermentation of "Levan" by Pneumococci.

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The studies of Hiss[1] show that inulin is fermented by the pneumococcus organism and that this fermentation can be used as a method of differential diagnosis between the Pneumococcus group and the Streptococcus. Bergey[2] mentions a *Streptococcus inulinaceus* Orla-Jensen, which also ferments inulin. A differentiation between these two organisms can be made by using other sugars. Among fungi, the presence of an inulase appears to be widespread, and inulin decomposition has been observed both among higher and lower types. Bourguelot[3] found inulase in *Aspergillus niger;* Grüss[4] in *Ustilago maydis;* Dean[5] in *Aspergillus niger* and a Penicillium; Frou[6] in Morchella; Wehmer[7] in a species of Mucor; Hanzawa[8] in *Rhizopus delemar;* and Castellani and Taylor[9] in *Monilia macedoniensis.*

In view of the work of Harrison, Tarr and Hibbert[10] and of Hibbert, Tipson and Brauns[11] on the constitution of levan and its relation to inulin, it seemed of interest to investigate the fermenta-

[1] Hiss, P. H., *J. Exp. Med.*, 1905, **7**, 547.

[2] Bergey's Manual of Determinative Bacteriology, 1930.

[3] Bourgelot, E., *Comptes rend.*, 1893, **116**, 1143.

[4] Grüss, J., *Berichte d. deutsch. botan. Gesellsch.*, 1902, **20**, 213.

[5] Dean, A. L., *Botanical Gazette*, 1903, **35**, 24.

[6] Frou, Cr., *Comptes rend.*, 1905, **140**, 1187.

[7] Wehmer, C., *Lafar's Handbuch der techn. Mykologie*, 1905, **4**, 527.

[8] Hanzawa, J., *Mykolog. Zentrbl.*, 1912, **1**, 76.

[9] Castellani, A., and Taylor, F. E., *Biochem. J.*, 1922, **16**, 655.

[10] Harrison, F. C., Tarr, H. L. A., and Hibbert, H., *Can. J. Research*, 1930, **3**, 449.

[11] Hibbert, H., Tipson, R. S., and Brauns, F., *Can. J. Research*, 1931, **4**, 221.