Discussion

No elaborate analysis of the figures is justified when the initial hypotheses are borne in mind. However, it may be noted that the first of these hypotheses is confirmed. If the P and E groups (there were no cross-diagnoses between these groups) are compared in respect of those with a history of deprivation of any kind and those without such a history, there is a significant difference between them ($\chi^2=6.7$, $P=0.01$). This difference could be interpreted as indicating that deprivation of parents increases liability to mental ill-health (though no figures for a probably more important history of unhappiness, brutality, etc., are available). Alternatively, it could be claimed that the mentally unstable tend to exaggerate a history of parental loss, or that they inherit their predisposition from parents whose own instability contributed to the breakdown of home life. Or, again, it is possible that the mentally healthy forget or gloss over parental deprivation. The difference between the two head injury groups is in the expected direction, but is small and not significant.

The effects of wartime evacuation of children, and war service by the father, on these statistics, which were collected during 1956 and 1957, are very obvious in the high incidence of separation from parents in the early age groups.

The Table shows also a high recorded incidence of death of fathers, and, to a less degree, mothers, for the age group 0-5 years. In this connexion it should be remembered that this group covers six years of life, unlike the other groups. Wartime casualties, particularly among the fathers, must also be considered. Even so, the incidence of maternal deaths in this period still seems high, and may be accounted for (a) because in the case of the P and HS groups such maternal loss does, in fact, cause behaviour disturbances, or (b) because of unreliability inherent in the nature of the inquiry. While it is reasonable to compare the different groups, the absolute figures may need to be treated with caution because of the rigid form of the questions asked. There was no mandate for questions about illegitimacy or adoption; and, indeed, to ask such questions of a patient referred for E.E.G. examination because he had crashed his aircraft and sustained a head injury might have led to justifiable complaints. Consequently the figures for the 0-5 age group, in particular, may be distorted owing to untrue or evasive answers.

Summary

The frequency of deprivation of parents during the childhood of a series of young Service men was investigated in relation to diagnosis. Significantly more of those who were psychiatric cases had a history of deprivation than cases referred on account of isolated epileptic attacks.

There was not a significant difference between a group of persons responsible for accidents and a control group.

The investigation was possible because of the co-operation of the electrophysiological technicians of the department. I thank Group Captain V. H. Tompkins, principal specialist in neuropsychiatry, Royal Air Force, for his encouragement. The present investigation was among those carried out during the period of tenure of a British Medical Association Research Scholarship.

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RESPIRATORY INADEQUACY AFTER THORACIC SURGERY IN TUBERCULOUS PATIENTS

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Respiratory function is always impaired to a greater or lesser degree after thoracic operations. The following factors, acting singly or in combination, are likely to reduce pulmonary ventilation: infection; paradoxical respiration, especially following thoracoplasty; lobar or lobular atelectasis; compression of the lung by air or fluid; pulmonary congestion or oedema; reduction of functioning lung tissue by disease or resection; wound pain, limiting chest expansion; and drugs, particularly analgesics and sedatives.

Most patients have a respiratory reserve sufficient to surmount these temporary difficulties, and measures such as physiotherapy, water-seal drainage, antibiotic therapy, and occasional bronchoscopy are usually adequate to prevent serious complications in the post-operative period. Many, however, whose respiratory reserve is grossly reduced by disease are now accepted for surgery. We have anaesthetized several with a pre-operative maximal voluntary ventilation (M.V.V.) of less than 30 litres a minute and in one it was as low as 17 l./min. Such patients require very careful pre-operative preparation, meticulous anaesthetic and surgical technique, and vigilant post-operative supervision.

Occasionally, despite careful post-operative management, the usual measures do not prevent the development of respiratory inadequacy, the features of which are due to hypoxia and carbon dioxide retention. When the main cause of respiratory insufficiency is atelectasis, ventilation may be sufficient to maintain the carbon dioxide tension of the blood within the normal range, but hypoxia may be severe as a result of impaired diffusion of oxygen and the shunting of blood through non-ventilated alveoli. When hypoventilation is due mainly to factors other than atelectasis, both hypoxia and carbon dioxide retention will be present. It must be noted, however, that the administration of oxygen to such patients will relieve the hypoxia and thereby remove the reflex respiratory drive from the chemoreceptors, thus aggravating the retention of carbon dioxide.

Method

When it was decided that respiratory inadequacy was present, a wide-bore cuffed tube was passed under direct vision laryngoscopy through the mouth into the trachea. If the patient was not already deeply unconscious, light general anaesthesia was induced to facilitate intubation. A period of hyperventilation through soda-lime followed, the patient's level of consciousness being assessed from time to time. A tracheostomy was made through the second and third tracheal rings in those patients who had considerable retention of secretions and who were likely to require a respirator for more than 24 hours. A shortened endotracheal tube fitted with a Magill T piece was inserted into the trachea, the cuff inflated, and connexion made to a mechanical respirator. Secretions were aspirated at frequent

intervals through a Tiemann catheter which had been modified by shortening and smoothing the tip so that it might be passed in turn easily and atraumatically down each main bronchus. In the five cases described the "pneumomatic" respirator was used (Horton, Inkster, and Pask, 1956). An air-entraining device attached to an oxygen cylinder provided an air/oxygen mixture to operate the machine and ventilate the patient. A humidifier of the type described by Marshall and Spalding (1953) was inserted between the respirator and the patient.

Case 1

A thin, undernourished man of 43 was found in 1938 to have bilateral pulmonary tuberculosis. In 1942 a right artificial pneumothorax and phrenic crush was carried out. In March, 1956, the vital capacity was 1,810 ml., the timed vital capacity was 1,120 ml. in 2 seconds, and the M.V.V. 38 l./min.

Differential lung function tests at that time were as follows:

		Tidal Air	Vital Capacity	Oxygen Uptake
Right lung	..	15 ml.	50 ml.	19 ml./min.
Left "	..	250 "	1,450 "	235 "

In April, 1956, a right pneumonectomy was performed. The immediate post-operative condition was satisfactory, but on the following day respiration became shallow and bubbling and the patient lapsed into unconsciousness. Bronchoscopy was carried out, and had to be repeated twice in the following four hours to remove accumulated secretions. Since respiration remained inefficient and laboured, tracheostomy was performed and intermittent positive-pressure respiration (I.P.P.R.) commenced. Radiological examination on the next day showed full expansion of the left lung. The respirator was used for 10 days. At the time of writing this patient was still receiving sanatorium treatment but his condition was satisfactory.

Case 2

The patient was a woman of 52 with bilateral pulmonary tuberculosis. In December, 1956, she had a right upper thoracoplasty. Her post-operative course was rather stormy; she had some paradoxical breathing and was cyanosed without oxygen, but she recovered without artificial respiration. In March, 1957, the M.V.V. was 21 l./min. Left upper thoracoplasty was carried out in May. The immediate post-operative state was fairly satisfactory, but gradually, over the next fortnight, the patient became more and more dyspnoeic. She appeared to be exhausted and was unable to cough effectively. After 15 days she was confused, disorientated, and cyanosed without oxygen. Tracheostomy was carried out and I.P.P.R. started. The carbon-dioxide-combining power of venous blood was 98 volumes per 100 ml., and by the following morning this had increased to 106 volumes per 100 ml. Once the initial difficulties in tolerating the tracheostomy tube had been overcome the carbon-dioxide-combining power fell steadily and after five days was 75 volumes per 100 ml. The respirator was in use continuously for six days and weaning took a further three days, after which recovery was uninterrupted and the patient was discharged to a sanatorium a month later.

Case 3

A small, thin woman of 25 had been under medical treatment for bilateral pulmonary tuberculosis since 1950. In February, 1957, a right extrapleural plombage was carried out. In March her lung functional capacity was as follows:

Test	Actual Result	Predicted Result
M.V.V.	19 l./min.	90 l./min.
Vital capacity	1,100 ml.	3,100 ml.
Timed V.C.	700 ml. in 2 secs.	2,700 ml. in 2 secs.

She had no dyspnoea when at rest in bed. In April a right upper thoracoplasty was carried out under general anaesthesia and the plomb removed. The patient recovered consciousness rapidly following the operation and was returned to the ward. Within a few hours, however, the respiratory paradox increased and the level of consciousness became depressed. When the anaesthetist was recalled, a cuffed tracheal tube was passed and hyperventilation was carried out manually through a Waters canister for an hour with frequent aspiration of secretions. She recovered consciousness but tolerated the tube well. Thereafter, I.P.P.R. was continued with the pneumomatic respirator via the tracheal tube for 12 hours. A radiograph of the chest showed that the lungs were well aerated. The concentration of electrolytes and the carbon-dioxide-combining power of venous blood were within normal limits. Following withdrawal of I.P.P.R. spontaneous respiration rapidly became adequate, and thereafter her convalescence was uneventful.

Cases 4 and 5

These two cases have been reported more fully by Robson (1958).

Case 4.—A woman of 46 had twenty years' history of pulmonary tuberculosis. Seventeen years previously, she had had a right upper seven-rib thoracoplasty, which, however, had not closed the cavity. The disease was unilateral and tubercle bacilli were present in the sputum. A right pneumonectomy was carried out under general anaesthesia. Nine days after operation she developed an infection in the other lung, and respiratory efficiency was further impaired by continuing paradoxical respiration. On the twelfth day after operation she was cyanosed and unconscious. At this time the oxygen saturation of the arterial blood was 65%, the arterial carbon dioxide content 97 vols. per 100 ml., and the pH 7.3. After she had been intubated and hyperventilated with oxygen, a tracheostomy was made and respiration taken over by the pneumomatic respirator. Subsequent gas analysis of the arterial blood showed a steady decline in carbon dioxide content with a rise in oxygen saturation to normal levels. Artificial respiration was continued for three weeks, by which time the right thoracic cage had healed firmly and there was no paradox when the patient breathed spontaneously.

Case 5.—A right upper four-rib thoracoplasty was performed under general anaesthesia on an emaciated, ill-looking man of 58. Two months previously a right upper lobectomy and apical lower segmental resection had been carried out. On the fourth day after the thoracoplasty an obvious bronchopleural fistula developed from an empyema cavity which communicated with the subscapular space. The patient was cyanosed and dyspnoeic. He was intubated and ventilated manually until his condition improved. Then a tracheostomy was made and I.P.P.R. by respirator initiated and continued for 24 days. Fourteen days after I.P.P.R. was discontinued the patient died of coronary thrombosis. At necropsy there was, in addition, a small area of necrosis on the posterior wall of the trachea. This was almost certainly due to pressure by the tip of the inadequately curved tube.

Discussion

Björk and Engström (1955) described the treatment of 15 patients with respiratory insufficiency following pulmonary resection by tracheostomy and prolonged artificial ventilation. Their patients were classified in two groups: (1) those who developed infection in the only functioning lung, and (2) those who already had a "compensated ventilatory insufficiency" before operation.

We have already mentioned the factors which may, singly or collectively, cause post-operative respiratory inadequacy. In our experience, respiratory paradox and infection have been the most important in those cases requiring treatment by I.P.P.R., which is, of course, only a temporary expedient

to maintain pulmonary ventilation until these complications can be controlled. During the actual operation paradox is prevented by controlled ventilation. However, it may occur when spontaneous respiration is resumed after operation. This risk remains so long as the chest wall is mobile, which may be a matter of weeks. Most patients compensate for this by an increase in tidal volume. But when the vital capacity is little more than the tidal volume there is no possibility of effecting much increase, and a small degree of paradox may precipitate ventilatory insufficiency (Case 2). Equally, respiratory paradox, when associated with some other pulmonary complication—for example, infection—may make it necessary to assist respiration (Case 4). In four of the five patients described above, paradox was an important factor. In three of them artificial respiration was continued until the chest wall was firmly healed.

The pneumomatic respirator has proved efficient and reliable. Various minor technical difficulties in the working of the machine over long periods have been encountered, but these have been reduced to a minimum by regular maintenance. An oxygen cylinder and a Waters canister containing soda-lime are kept constantly available at the bedside lest difficulty with the machine should develop. The nursing staff in attendance are instructed in the technique of manual ventilation so that they can, should the need arise, keep the patient alive until medical help arrives.

In the day-to-day management of these patients clinical appraisal is most important. Sweating and a rise in blood pressure usually signify carbon dioxide retention. Frequent clinical and radiological examination is necessary to ascertain that air entry into the chest is adequate. Air flow may be interrupted partly or completely by such factors as secretions, kinked tubing, prolapse of the cuff, or an excessively long tracheostomy tube. Obstruction from this latter cause is most likely to occur if the tracheostomy has been made too low. A pressure-cycled machine will continue to operate even if the airway is completely obstructed, since it is triggered by pressure of gas within the machine. In these circumstances the rate will increase, since the "blow off" pressure is reached more quickly. Nurses are taught to observe the patient's colour and the rise and fall of the chest, and to report any increase in the rate of operation of the machine. Pulmonary secretions are tested for antibiotic sensitivity and the appropriate drug is given.

Most of our patients have had a low-grade pyrexia which cleared up rapidly after the tracheostomy tube was removed. Water must be drained from the expiratory side of the circuit and the temperature of the humidifier checked at regular intervals. The patient's position is changed every few hours to prevent hypostatic congestion, to encourage postural drainage of secretions, and to avoid bedsores. Pressure on the trachea by the endotracheal tube and cuff has, however, been a problem (Case 5). In an attempt to minimize this danger the cuff is deflated for a few minutes every two hours. The length of time that it can remain deflated is limited, since cycling is prevented by the escape of gas round the tube and the machine is brought to a standstill. Damage due to movement or pressure of the shortened endotracheal tube should be reduced to a minimum by a moulded rubber tube of the type described by Spalding and Smith (1956). Since pooling of pharyngeal secretions may occur above the cuff, pharyngeal toilet is carried out immediately before it is deflated, and suction through the tube is practised while it is collapsed. The tracheostomy tube is left until a firm track has formed, usually in four or five days. Thereafter it is changed every two days or oftener if there is any danger of the tube becoming blocked by secretions. The tracheal stoma is cleaned with ribbon gauze; cotton-wool should not be used as fragments may be left in the trachea.

The importance of having well-trained and alert nurses cannot be too strongly emphasized. Patients on I.P.P.R. become very dependent on the machine and on their usual medical and nursing staff. A new nurse must not be left in sole charge until she is thoroughly capable of dealing with

any emergency which may develop and, if the patient is conscious, until she has fully gained his confidence. Respirator patients quickly detect any lack of experience or knowledge on the part of their attendants and may become apprehensive. The confidence of the patient is particularly required during weaning from the machine. At this stage a patient-triggered respirator is a great advantage. Short spells of spontaneous respiration are gradually lengthened until I.P.P.R. is no longer necessary.

These patients are in some respects difficult to manage. Functioning lung tissue is reduced, sometimes markedly, so that it may be difficult to hyperventilate the patient and correct an existing respiratory acidosis. Lung compliance is often reduced, and a higher pressure of gas than usual may be required to expand the lungs. Infected secretions from the tracheo-bronchial tree or from the tuberculous cavity may necessitate very frequent aspiration. If the trachea is irritable, spasms of ineffective coughing may be provoked, distressing the patient and hindering the proper working of the machine. Generally, however, the tube is well tolerated, though sedation may be required for the first day or two.

On the other hand, since the patient is not paralysed, general nursing is easier. Physiotherapy is facilitated, since active movements are possible. Although an intragastric tube is employed for feeding in the first few days, the patient is soon able to feed himself. He is better able to communicate his needs and worries to the nursing staff and is also able to read or interest himself in other ways, which is a considerable help to his morale.

Summary

Various factors which adversely affect respiratory efficiency after thoracic operations are reviewed.

A method of treatment of respiratory inadequacy by tracheostomy and intermittent positive-pressure respiration is described and illustrated by five case reports.

The important role of respiratory paradox in precipitating respiratory inadequacy is emphasized and some practical points in management are discussed.

In the efficient management of patients with respiratory inadequacy team-work is of the utmost importance. It is therefore a pleasure to acknowledge the valuable help and co-operation which we have received from our medical and surgical colleagues both in the treatment of these cases and in the preparation of this paper.

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Mr. RICHARD THOMPSON, Parliamentary Secretary to the Ministry of Health, speaking at a meeting of the Association of Hospital Management Committees at Southport on June 12, drew attention to four "deeply significant" features in the history of the past 10 years of the hospital service. First was the better use of beds. The rise in available "staffed" beds between 1949 and 1957 had been 6%, but the number of in-patients treated in them had risen by 30% during the same period. Secondly, the growing importance of out-patients departments. The number of out-patients seen at consultative clinics had increased by more than 12%, from 6,148,000 in 1949 to 6,907,000 in 1957. Thirdly, the comfort and convenience of out-patients had been studied, and attention devoted to the reduction of waiting time. Lastly, there had been a striking change in the outlook towards mental health, both on the part of the public and the hospitals. More patients were coming forward for treatment voluntarily and at an early stage. The proportion of voluntary admissions had risen from 59% in 1949 to 78% in 1957.