RESPIRATORY SEQUELAE OF ANAESTHESIA IN MILITARY PRACTICE

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IN a report published in this Journal in May, 1942, I described experiences with an Australian military hospital in Egypt. I then reported an incidence of postanaesthetic respiratory infection which at times reached 4 per cent, a figure high by civilian standards. Inquiries among other military anaesthetists revealed the clinical impression that such sequelae are frequent in military hospitals, whether in Egypt, England, or Australia. Exact statistics, however, were seldom forthcoming; indeed, few papers on the subject have appeared in the recent literature of anaesthesia, so far as I am aware. Military anaesthesia is generally pragmatic and research is little encouraged; the subject, however, seems to merit pursuit, both in Base Hospitals (in which the working conditions approximate those of civilian practice) and especially in tent hospitals in the field.

Since returning from Egypt, our hospital has functioned under canvas in two localities in northeastern Australia. The climate is subtropical: there are but two seasons, wet and dry. The former coincides with the summer months (October to April), and is hot and rainy. The dry season is almost rainless, dusty, and (in June and July) cool enough to render light woolen clothing desirable.

THE INCIDENCE OF RESPIRATORY SEQUELAE

Table 1 presents the incidence of respiratory sequelae in 693 anaesthetic administrations, covering a period of fourteen months ending August 31, 1943. Personal administrations are alone included, for the sake of uniformity in criteria. The incidence of respiratory sequelae (3.6 per cent) compares with the most unfavourable incidence encountered in Egypt.

In the consideration of this table, it should be remembered that ether was never employed in the presence of pulmonary disease, nitrous oxide, with minimal ether supplement, was used mainly in the presence of a definite indication, such as pulmonary disease, surgical shock, or an operation of unusual severity, and spinal analgesia was employed mainly for its convenience in perineal operations. The series of cases is too small for any conclusion to be drawn from them, but there is a widespread clinical impression that spinal analgesia in the lower abdomen has much the same rate of sequelae as does ether anaesthesia.

TABLE 1

RESPIRATORY SEQUELAE

Anaesthetic	Cases	Respiratory sequelae, cases	Respiratory sequelae, per 100
Ether			
(*a*) "Open" method	470	17	3.6
(*b*) Endopharyngeal	10	1	(10.0)
(*c*) Endotracheal (Magill oral or nasal)	60	—	—
Ethyl chloride	2	—	—
Nitrous oxide			
(*a*) Unsupplemented	11	—	—
(*b*) Ether supplement	78	7	(9.0)
(*c*) Endotracheal	4	—	—
Pentothal sodium, unsupplemented	16	—	—
Spinal analgesia, unsupplemented			
(*a*) Perineal	36	—	—
(*b*) Lower abdomen, limbs	6	—	—
Total	693	25	3.6

THE PREOPERATIVE CONDITION OF THE PATIENT

Any analysis of postanaesthetic respiratory sequelae must take into consideration the preanaesthetic condition of the patient. The soldier patient is at a disadvantage in comparison with the civilian. He lives a strenuous, outdoor life in a trying climate. He is exposed to heat, dust or rain; he lives in crowded surroundings favourable to the interchange of respiratory organisms. His surgical lesion is usually an acute disability, which leads to his rapid removal to a hospital staffed by complete strangers. Here, he is subjected to operation with a minimum of delay, and under adequate but very simple conditions. His recovery is made in a tent in the open field. It is not surprising, therefore, that the psychologic and physical course of a surgical illness runs somewhat less smoothly in a field hospital than in a civilian hospital dealing with the elective surgery of peacetime.

A characteristic feature of soldier patients is the prevalence of more or less catarrh of the upper respiratory passages, a condition bearing popular names such as "smoker's cough" or (in Egypt) "desert lung." Upon this widespread basis of respiratory catarrh is superimposed, from time to time, an acute infection which may be endemic or epidemic, and known variously as "influenza," "URTI" (upper respiratory-tract infection), "Puckapunyal throat" or other local cognomen. Such an epidemic may sweep suddenly through a unit, a hospital, or a single ward in a hospital, without warning, and quite apart from any considerations of anaesthesia.

The widespread incidence of chronic catarrh of the upper respiratory tract among soldiers is illustrated in a series of 150 consecutive patients, subjected to general anaesthesia. The results are tabulated as in table 2.

It will be seen that, of 150 patients, 64 or 42.6 per cent gave a history of varying degrees of cough and expectoration. Physical signs in the

TABLE 2

INCIDENCE OF CHRONIC CATARRH IN 150 CONSECUTIVE SURGICAL CASES

Respiratory history	Patients	Physical signs in lungs	Postanaesthetic lung infections
No respiratory symptoms	86	1	2
Recent coryza; persistent cough	29	1	2
"Smoker's cough"	28	2	2
Recurrent bronchitis	3	1	2
Hay fever	1	–	–
Nasal sinusitis	2	–	–
Emphysema	1	1	–
Total	150	6	8 (5.2%)

lungs, e.g. rhonchi or râles, were uncommon; it would seem that considerable respiratory catarrh may exist without signs which may be detected by the stethoscope, at least in my hands.

It is reasonable to expect that, when patients suffering from respiratory catarrh are subjected to anaesthesia (especially with an irritating anaesthetic), and to operation, postoperative respiratory changes, such as bronchitis and atelectasis, will develop in a certain proportion. Some confirmation of this is suggested in table 2. The respiratory rate of sequelae in this small series was 5.2 per cent (8 in 150 cases). Of the 86 patients without a history of catarrh, bronchitis developed in only 2 (or 2.3 per cent), although ether was chiefly employed in these cases. Of 64 patients with a catarrhal history, bronchitis developed in 6 (9.4 per cent), and this despite the fact that every patient with symptoms or apparent physical signs received gas or pentothal anaesthesia.

It may be concluded, then, that a high percentage of soldiers suffer from catarrh of the upper respiratory passages, amounting at times to a "subclinical" bronchitis, and engendered by crowded living conditions, dust, exposure, and over-smoking. Where the symptoms are obvious or associated with bronchitic signs, a high incidence of postoperative respiratory infection may be anticipated, even though a nonirritant anaesthetic is employed. Careful preanaesthetic examination of patients, therefore, is an important factor in mitigating respiratory sequelae, although the early signs of catarrhal bronchitis are likely to elude our present stethoscopic methods of examination.

THE INFLUENCE OF THE OPERATION

Certain operations are, in military practice, more likely to be followed by respiratory sequelae than are others. This point is well exemplified in the present series of cases, which may be classified from the standpoint of the types of operations performed, as shown in table 3.

It appears from these figures that herniotomy carried the highest rate of respiratory sequelae (14 in 85 cases, or 16.5 per cent). Next was abdominal section (7 in 72 cases, or 9.7 per cent). Orthopaedic operations

yielded an incidence of 1.5 per cent (2 in 131 cases), while in a group of miscellaneous surgical operations the incidence was only 0.8 per cent (2 cases in 258 operations). In 147 operations (for gunshot wounds and operations upon the nose, throat and perineum) respiratory sequelae were not associated.

TABLE 3

RELATIONSHIP OF RESPIRATORY SEQUELAE TO TYPES OF OPERATION AND ANAESTHESIA

Type of operation	Cases	Ether	Gas	Pentothal	Spinal	Respiratory sequelae
Abdominal section	72	64	8	—	—	7 (ether, 4; gas, 3)
Hernia, hydrocoele	85	64	17	—	4	14 (ether, 11; gas, 3)
Anus, perineum	65	19	10	2	34	—
Battle casualties	55	49	4	1	1	—
Orthopaedic	131	124	6	—	1	2 (ether)
Otolaryngology	27	22	1	4	—	—
Miscellaneous	258	200	47	9	2	2 (ether, 1; gas, 1)
Total	693	542	93	16	42	25 (ether, 18; gas, 7)

The high incidence after herniotomy or abdominal section is probably connected with the postoperative immobility enforced upon such patients, whether by the surgeon's wishes or by pain. Further, reduction of diaphragmatic excursions and consequent hypoventilation of the lungs are familiar concomitants of abdominal operations and factors in the production of postoperative atelectasis. They are not the sole factors; if they were, treatment with carbon dioxide and the "stir-up regimen" might well be of absolute, instead of relative, value in prevention. At the same time, it is probably true that factors, such as pain and immobility, making for atelectasis, are responsible for the high incidence of respiratory complications after herniotomy or coeliotomy, higher than after other operations.

THE EFFECT OF THE ANAESTHETIC

In the present series, 18 cases of respiratory infection followed ether anaesthesia, and 7, nitrous oxide anaesthesia with minimal ether supplement. The respective ratios to the total number of administrations were 3.3 per cent in the case of ether and 7.5 per cent in that of nitrous oxide. The high incidence after gas anaesthesia is due, of course, to the fact that this method was employed for those patients in whom respiratory complications were apprehended.

Of the 7 cases in which respiratory infection developed after nitrous oxide anaesthesia, 3 occurred in frankly bronchitic subjects, the bronchitis being merely exacerbated by anaesthesia and operation. The operations performed were, respectively, herniotomy, appendicectomy and nephrectomy. The 4 remaining patients presented "smoker's cough" in three instances and recent coryza in one; the operations were herniotomy in 2 patients, nephrectomy in 1, and cholecystectomy in one. In other words,

all were major operations and the preoperative respiratory condition of every patient was abnormal.

The 18 cases of respiratory infection after ether anaesthesia fall similarly into two groups. The first group (6 patients) gave a history of "smoker's cough" or recent coryza without abnormal physical signs in the lungs, and the second group (12 patients) apparently were healthy. In the first group (which included an orthopaedic operation, a thyreoid adenomectomy and 4 herniotomies) the choice of anaesthetic may have been open to criticism. Respiratory catarrh is of such frequency in the Army that it is likely to be treated lightly in the absence of positive physical signs in the lungs, and it may be that even in these mild cases the decision to use ether was in error. The 12 cases in which the patients apparently were healthy included 1 orthopaedic operation, 4 abdominal sections and 7 herniotomies. There seemed to be no reason why ether should not have been administered to these patients.

Respiratory catarrh, then, is frequent in the Army, and it is difficult by present methods to estimate its severity or predict its response to anaesthesia and operation. This is an argument for the use of a non-irritating anaesthetic, so that direct insult to the bronchial tree may be avoided. Unfortunately, it is not easy to find an anaesthetic which, in routine use, will have the many advantages of ether without its irritating properties. Ether is therefore likely to remain the "standard" inhalation anaesthetic in the Australian Army, and the question becomes one of the recognition of patients unfit for it and their handling under some other form of anaesthesia.

It is probable that the presence of râles or rhonchi in the lungs is a contraindication to ether, as is also marked cough and expectoration, especially if the latter is mucopurulent. The presence of "smoker's cough" or nonpurulent expectoration does not necessarily contraindicate ether in the majority of operations, but probably does in herniotomy or coeliotomy, where respiratory sequelae are so likely to eventuate. The decision is necessarily individual for each case, and unfortunately cannot be based upon clearly-defined physical signs. Errors in judgment, therefore, are likely to occur, and may be paid for by the patient in respiratory infection.

If ether is excluded, one is left with a choice of nitrous oxide, spinal analgesia, local analgesia and anaesthesia with pentothal sodium. Few would advocate the routine use of the last-mentioned drug in major surgery. Local analgesia, among other drawbacks, has the cardinal defect of being too time-consuming to be practicable in a busy military hospital. There remain nitrous oxide and spinal analgesia. The former is of wide application, but could not be advocated for routine use by all anaesthetists. Even when capably administered and supplemented to a reasonable extent with ether, it confers but limited muscular relaxation in a robust, athletic young soldier undergoing an abdominal section.

Spinal analgesia is so easy, so expeditious, and associated with such excellent muscular relaxation that many anaesthetists have advocated it

as a routine practice in military surgery. Since most military operations are concerned with the lower limbs, perineum, groin and lower abdomen, the technic may be employed with relative safety. I have little hesitation in using it for perineal and rectal operations, and have not yet encountered respiratory sequelae in such patients. The use of spinal analgesia for lower abdominal operations possibly is in another category. I do not have evidence as yet for any comparison of spinal analgesia with gas or ether anaesthesia in this type of operation. The problem should be worked out in military hospitals, both in healthy subjects and in those suffering from respiratory disease. For both upper abdominal and thoracic operations, I prefer inhalation anaesthesia.

THE NATURE OF THE RESPIRATORY INFECTION

There were 25 cases of postanaesthetic respiratory infection in the series. They followed, in the main, a common course. The patient's temperature became elevated to approximately 101 F. within twenty-four to thirty-six hours after operation. Cough developed, and the sputum became thick and purulent. Bronchitic signs were audible in 3 of every 4 patients, but were not necessarily generalized. The pyrexia subsided within twenty-four to thirty-six hours, but purulent expectoration continued for two or three days after the onset. The condition then subsided rapidly, the lungs being normal on auscultation by the third or fourth day.

Two cases were mild and transient, and the majority were of only moderate severity. Only 2 patients were seriously ill. In one, who suffered from a chronic cough, severe bronchitis developed after herniotomy. In the other who suffered from "smoker's cough," lobar pneumonia developed (possibly upon an atelectatic basis) after nephrectomy, and the patient was seriously ill for a week.

Atelectasis was almost certainly present in one patient, whose symptoms appeared suddenly and disappeared equally suddenly within a period of thirty-six hours. Four other patients were suspected of having atelectasis because of diminished aeration of a particular area of lung, usually one or the other base. This could not be confirmed without radiography, which was impracticable in our circumstances, and the whole part played by atelectasis in the syndrome must remain uncertain. Similarly, bacteriologic investigation was confined to a few, isolated, sputum cultures. They revealed only pneumococci, which may well have been habitual inhabitants of the patients' bronchial tree.

PREVENTION

It will be seen from the foregoing observations that, in 693 anaesthetic administrations to soldiers, the incidence of respiratory infection averaged 3.6 per cent. The lesion was mainly an acute bronchitis, with a possible basis of atelectasis; it was rarely severe, but one would not be justified in presuming upon this fact. The very occurrence of such infection is dis-

quieting for it means that, even with careful technic, a certain proportion of the patients will be injured by the anaesthetist's efforts in their behalf.

It seems impossible to assign the respiratory sequelae of military anaesthetic practice to any one cause, and therefore to find any one remedy for them. At least three major causal factors are involved, viz., the preanaesthetic condition of the patient's respiratory system, the nature of the anaesthetic employed, and the degree of bodily immobility of diaphragmatic stasis enforced by the operative procedures. Hence, the problem of prevention may be attacked only upon general lines, by close attention to a number of details, the neglect of any one of which may defeat the whole plan of campaign. A series of recommendations, therefore, have been drafted, but they are necessarily based upon established principles and only their practical importance can excuse their lack of originality.

1. *Preanaesthetic Examination of the Patient.*—It is of cardinal importance that inquiry be made into the condition of the respiratory system. In the presence of frank disease, such as chronic bronchitis, the selection of an appropriate anaesthetic agent and technic will offer no great difficulty. The presence of catarrh, however, with few or no physical signs, should not be overlooked, and a nonirritating anaesthetic should be chosen accordingly. When in doubt, the anaesthetist should always err, if at all, on the side of the safer agent.

It is sometimes desirable, especially before a major operation, to make a deliberate attempt to improve the patient's respiratory condition. The patient may not be willing to give up tobacco for the time being, but even limitation of smoking for two or three days will exert a beneficial effect upon "smoker's cough." Rest in bed, the maintenance of an even temperature, the use of inhalations, postural coughing and breathing exercises will help to bring the respiratory mucous membrane into a more nearly normal state, and so reduce the ultimate hazards of anaesthesia and operation.

2. *Premedication.*—Heavy premedication, which may delay the return of movement and of the cough reflex, is undesirable as a routine practice, and especially so before rhinolaryngologic or dental operations.

3. *Warmth.*—It is too often forgotten, even in civilian hospitals, that clothing adequate for a conscious person engaged in work is quite inadequate for an anaesthetized patient, whose heat-regulating mechanism is temporarily in abeyance. This consideration has even greater force in the field. The patient must be warmly clad and well wrapped in blankets during the long ambulance journey from ward to operating theater. The latter should be heated to 70 F. before operating commences and should be maintained at this temperature; communicating doors too frequently are left open, with consequent chilling of the operating room. During the operation, the patient's skin should not be exposed more widely than is necessary, and he should be provided with a chest blanket and hot-water bottles. Large shawls, of soft and loosely-knitted wool, have proved very useful in our hospital as coverings for the upper portion of the pa-

tient's body. At the end of operation, the patient should be well wrapped for the return journey to the ward, and that journey should be made without avoidable delay.

4. *The Anaesthetist's Responsibility.*—The anaesthetist is ordinarily responsible for the choice of endotracheal anaesthesia in appropriate cases and, on occasion, for the insertion and renewal of pharyngeal packs. He should take every care to avoid depression of the respiratory centre by unduly deep anaesthesia, oxygen-lack or carbon dioxide excess. He should avoid the exhibition of highly concentrated and irritable vapours, remembering that these are as harmful to the anaesthetized as to the conscious patient, although the former may be no longer able to protest against them.

5. *Suction Drainage.*—Provision must be made for the aspiration, as often as may be necessary, of mucus, blood or pus from the pharynx, endotracheal catheter or bronchial tree.

6. *After-care.*—Attendants entrusted with the transportation or supervision of the anaesthetized patient should be previously instructed in their duties and in the emergencies which they may encounter. They should be taught to keep the patient (especially if he is bleeding or vomiting) upon his side, without a pillow and with his head low. It should be impressed upon them that no patient may be left alone, even momentarily, until he has so far recovered as to be able to control his movements and attend to his own needs. They should be familiar with the causes and symptoms of anaesthetic overdosage and of respiratory obstruction. They should know when and how to reestablish the patency of the air passages with gag, fingers and artificial airway. They should know when and how to administer oxygen, and when to seek the assistance of the nearest medical officer.

7. *Lung Inflation.*—Atelectasis may result from diminished respiratory excursion caused by pain, immobility or diaphragmatic stasis; it also may result from increased bronchial secretion combined with ineffective expectoration. It is important, therefore, that after operation patients be encouraged to be as mobile in bed as their surgical condition will permit. At the least, they should be encouraged to sit up as soon as possible, or, if recumbent, they should be moved frequently from side to side. Inhalations of carbon dioxide are valuable in promoting ventilation of the lungs, but they must not be relied upon to the exclusion of other measures. The gas is supplied to the Australian Army in the pure state rather than admixed with oxygen. There remains, however, considerable misconception of the aims and technic of carbon dioxide therapy. The object of each treatment is to provoke two or three really deep inhalations by the patient; this attained, the alveoli have become expanded, and continuation of the treatment may only cause discomfort without any compensating gain. It should therefore be discontinued, to be resumed two or four hours later. It follows that the direction toward the patient's face, from a distance of a few inches, of a very gentle stream of pure carbon dioxide is a simple and effective way of attaining the desired results. It is more

likely to be satisfactory in routine hospital use than is any cut-and-dried formula of times, percentages and rates of flow. The supply of carbon dioxide in field hospitals does not enable every patient to receive treatment, but lung-inflations at four-hourly intervals should be given as a routine in cases of abdominal section or herniotomy, or in any case in which respiratory sequelae are to be expected.

Probably of greater importance even than carbon dioxide therapy is the "stir-up regimen," under which patients are encouraged to remain mobile, to practice deep breathing and to expectorate any sputum which may collect in the bronchial tree, even though expectoration may cause pain in the surgical wound. An eminent surgeon has suggested that, in place of the texts which adorn the walls of some civilian hospitals, a notice should be posted with the legend, "Cough It Up!" Better advice could not be given to the surgical convalescent. An experienced nurse will always, when passing by the patient's bed, take the opportunity to encourage him to press his hand upon his wound, to cough actively and so clear his lungs of secretion, and finally to take two or three deep breaths. It is noticeable in our hospital that the wards in which the medical officers are most conscious of the problem of postoperative respiratory sequelae, and have imparted their own interest to the nursing sisters, are those in which the case incidence is the lowest.

SUMMARY

1. The incidence of postanaesthetic respiratory sequelae, in a field hospital in northeastern Australia, was 3.6 per cent in a series of 693 administrations.

2. This high incidence may be related to the frequency of respiratory catarrh among soldiers, a condition apparently resulting from dust, crowded living and the excessive use of tobacco.

3. Some evidence exists to show a higher case incidence among patients suffering from respiratory catarrh than among normal subjects.

4. The rate of respiratory sequelae was very much higher after coeliotomy or herniotomy than after any other single operation.

5. The most frequent respiratory sequel was acute bronchitis, possibly occurring upon a basis of atelectasis. Twenty-five cases of respiratory infection are presented from the standpoint of the preanaesthetic condition of the patients and the suitability of the anaesthetics employed.

6. Recommendations are made for the prevention of respiratory sequelae, with special emphasis upon careful preanaesthetic examination of patients and selection of anaesthetic agents, the care of patients at and after operation, carbon dioxide therapy, and the all-important "stir-up regimen."

I am indebted, for permission to publish, to the Commanding Officer of the Hospital and to the Director-General of Medical Services, Australian Military Forces.

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