RESPIRATOR CARE IN A GENERAL HOSPITAL A FIVE-YEAR SURVEY

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INTRODUCTION

INTERMITTENT POSITIVE PRESSURE BREATHING has been widely accepted for the management of respiratory failure, and many excellent reports have dealt with problems of pulmonary ventilation and the clinical results of this method¹⁻⁹ Between January 1, 1960, and December 31, 1964, 201 cases of respiratory insufficiency were treated with the Bird respirator at Victoria Hospital in London, Ontario. In the following discussion, we intend to describe the types of patients given respirator care during this five-year period and present our assessment of the results of respirator care and the problems with infection, and our observations regarding the management of hopeless cases.

The indication we considered for the use of intermittent positive pressure breathing was inadequate pulmonary ventilation as determined by clinical evaluation of the patient, by spirometry employing the Wright respirometer, and by analysis of arterial blood gases. These same methods were used to assess the efficiency of treatment once it was begun. However, in a number of cases a catastrophe such as cardiac or respiratory arrest brought the seriousness of the respiratory problem to the fore and respirator treatment was only instituted after acute resuscitation.

PRESENTATION OF CASES

For the purpose of description the cases have been divided into the following five main groups based on the functional pathology.

1 Central Respiratory Depression

In 60 patients the respiratory insufficiency was the result of central respiratory depression caused by drug intoxication, cerebral trauma or infection, status epilepticus, or post-anoxic depression following cardiac arrest (Table Ia).

2 Spinal Cord and Neuro-Muscular Problems

Twenty-two patients suffered from paralysis of respiratory muscles. The Guillain-Barré syndrome and neuromuscular insufficiency associated with muscle relaxants comprised the majority of these cases. Myasthenia, tetanus, spinal cord injury, and a group of other neuropathies made up the remainder (Table Ib).

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TABLE I

	No of cases	Died	Survived
<i>a</i> Central Respiratory Depression			
Drug intoxication	10	1	9
Brain trauma	29	27	2
Brain infection	6	4	2
Status epilepticus	2	0	2
Post-cardiac arrest	13	11	2
<i>b</i> Spinal Cord and Neuro-Muscular Problems			
Guillain-Barre syndrome	8	1	7
Other neuropathies	4	2	2
Muscle relaxant	6	1	5
Tetanus	1	0	1
Spinal cord injury	1	1	0
Muscular dystrophy and myasthenia	2	0	2
<i>c</i> Skeleto-Muscular Problems			
Crushed chest	20	7	13
Post-thoracotomy	21	12	9
Post-abdominal	17	13	4
Chest deformity	1	1	0
<i>d</i> Pulmonary Parenchymal Problems			
Post-cardio-pulmonary bypass	18	12	6
Pneumonia	10	8	2
Diffusion defect	13	9	4
Respiratory distress syndrome	4	4	0

3 *Skeleto-Muscular Problems*

Skeleto-muscular disorders gave rise to respiratory insufficiency in 59 patients. Twenty patients with a crushed chest required positive pressure ventilation. Inadequate respiration after thoracic or abdominal surgery was the reason for therapy in the other 39 patients (Table Ic).

4 *Pulmonary Parenchymal Problems*

Eighteen patients were ventilated following cardio-pulmonary bypass. Advanced widespread pneumonia was the indication for respirator treatment in ten patients, while thirteen were treated for a variety of conditions associated with diffusion defects such as Hamman-Rich syndrome, pulmonary fibrosis, or pulmonary oedema. Four newborns with respiratory distress syndrome were treated without success (Table Id).

5 *Emphysema*

Fifteen cases of decompensated emphysema were treated, and eight survived.

DISCUSSION

Table II presents a summary of our 201 patients, showing the average length of respiratory treatment as well as survival rates. It should be noted that, in these five groups, the survival rate appeared to be directly related to the duration of respirator treatment. It would be fallacious to draw any conclusion from this mathematical relationship, however, and it is not possible to come to any critical

assessment of the efficiency of total respirator care on the basis of the above data or similar classifications based on diagnostic groupings¹⁻⁹ or physiological considerations¹⁰

TABLE II

Clinical condition	Total no. of cases	Died	Survived	Average duration of therapy (days)	Survival (%)
Central respiratory depression	60	43	17	4 8	28
Spinal cord and neuro-muscular problems	22	5	17	31 9	77
Skeleto-muscular problems	59	33	26	7 7	44
Pulmonary parenchymal problems	45	33	12	3 8	27
Emphysema	15	7	8	9 3	53

In evaluating the efficacy of respirator treatment based on survival and subsequent well-being, the prognosis of the underlying disease giving rise to the respiratory insufficiency must be considered. For this reason a selection was made of all patients in whom the underlying disease had a favourable prognosis, providing the respiratory failure was effectively treated.

In Table III, conditions with a potentially favourable prognosis have been listed, these patients should all have survived with efficient respirator care. The 46 patients classified here had a mortality rate of only 18 per cent. However, six of the eight deaths were due to the development of a pulmonary infection while the patient was on the respirator.

TABLE III
POTENTIALLY FAVOURABLE PROGNOSIS

Problem	Number	Survived	Died
Drug intoxication	10	9	1
Status epilepticus	2	2	0
Guillain-Barre syndrome	8	7	1
Muscle relaxants	6	5	1
Tetanus	1	1	0
Spinal cord injury	1	0	1
Myasthenia	2	2	0
Uncomplicated crushed chest	12	10	2
Other neuropathies	4	2	2
Total	46	38	8

Survival rate, 82%

This "respirator lung," as we termed the infection colloquially, usually began with bronchospasm and a decreasing compliance. Bronchodilators and higher inflation pressures improved ventilation at first but later became less and less effective. The chest film showed widespread bronchopneumonia. Finally pulmonary ventilation became impossible, very high inflation pressures could not force enough oxygen into the lungs to maintain adequate oxygenation. At autopsy the lungs had the consistency of liver, the alveoli being completely filled with inflammatory exudate.

This type of pathology was definitely responsible for the unsuccessful outcome of the respirator treatment in the six cases mentioned above. Similar pulmonary infections were observed in many other cases and may have been occasionally responsible for the death. Some patients survived the condition after treatment with massive doses of antibiotics, cortisone, and adrenalin. Of the organisms cultured from the bronchi in these cases, *pseudomonas*, coagulase positive *staphylococci*, *E coli*, and *proteus* were common in our respirator cases. Little attention has been given to this problem in the literature ¹¹

To reduce the alarmingly frequent appearance of the "respirator lung" the following attempts were made to control possible sources of infections

1 Suction bottles and tubing were changed and sterilized three times every day. Only autoclaved catheters were used for tracheal suction.

2 Stagnant water in nebulizers and tubings was eliminated by frequent changes of all attachments to the Bud respirator and by the discontinuation of all "Q" circle attachments. In the latter it was found that the condensing moisture contained large numbers of bacteria.

3 Nebulizers such as the Puritan and the Bird were sterilized before each use. *Pseudomonas* could be cultured from nebulizers that had been washed only between treatments.

4 As a further measure, disposable gloves were used routinely for every tracheal suction. Our bacteriologist reported a colony count ten times higher in suction procedures with the washed bare hands as compared to unwashed hands covered with disposable gloves ¹²

These changes, and particularly the routine use of disposable gloves, have been in full effect since November 1964. Although it would appear too early to assess fully the significance of these measures, no case of the "respirator lung" described above has been seen since that time. However, *pseudomonas* and *E coli* continue to be cultured, and crowded conditions make more effective controls impossible without interfering with the nursing care of the patient.

In Table IV conditions are listed which have a potentially unfavourable prognosis. Here only 17 per cent of the patients survived. In the other 64 patients, treatment of the respiratory failure was unsuccessful in influencing the fatal outcome of the underlying disease. Brain trauma and cerebral anoxia following

TABLE IV
UNFAVOURABLE PROGNOSIS

Problem	Number	Survived	Died
Head trauma	29	2	27
Cerebral anoxia (post-cardiac arrest)	13	2	11
Complicated crushed chest*	8	3	5
Extensive pneumonia	10	2	8
Diffusion defects	13	4	9
Respiratory distress syndrome	4	0	4
Total	77	13	64

Survival rate, 17%

*Associated with injuries to the brain, abdominal organs, or kidneys, or with multiple major fractures

cardiac arrest of sufficient degree to cause respiratory depression or persistent apnoea were almost always hopeless, less than 10 per cent of these patients survived and this is in agreement with other reports^{5,7} Patients suffering from these disorders presented a rather characteristic picture of "decay" Comment on the developments will provide a useful guide to their management Having shown temporary signs of recovery with the improved ventilation, the patients regressed into a deeper state of coma as judged by the disappearance of reflex responses previously present (Fig 1) The pupils became nonreactive to light and dilated Then the blood pressure fell, vasopressor support of the circulation, usually begun at that time, gradually diminished in effectiveness, and increasing doses were required Subsequently the body temperature began to fall to sub-normal levels The heart beat, as the last sign of life, usually became imperceptible when the body temperature had fallen to levels between 36° and 32° C This sequence of events lasted anywhere from 24 to 96 hours and, depending on the circumstances of the case, was associated with a variety of concentrated and costly therapeutic attempts

Respiratory arrest in patients with cerebral damage due to trauma, following an anoxic episode, or in the course of a brain infection, had an extremely poor prognosis In such a patient who was well ventilated and oxygenated, a progressive fall in blood pressure was probably indicative of a failure of the vasomotor centre A fall in body temperature indicated a breakdown of the heat-regulating mechanism Loss of cerebral function to this extent was not compatible with survival Experience has shown that treatment is futile at the stage of falling body temperature

In a last group of 78 patients a prognostic assessment could not be made in view of the many factors involved Pre-existing pathology, co-existing disease, and surgical intervention with subsequent secondary complications and functional derangements of which respiratory insufficiency was only one aspect, made it difficult or impossible to evaluate the efficacy of respirator treatment Objective improvement of the condition was observed in almost all patients after commencement of respirator treatment The high mortality of 64 per cent in this group was largely determined by the multiple respiratory and non-respiratory problems Pulmonary infection was often present in the terminal stages of these patients Although in all cases the respirator care was necessary for survival, in some the pulmonary complications introduced by this treatment could not be excluded as contributing to the fatal outcome

Respirator care of patients in a general hospital has been possible without a specially designed respiratory unit Patients were looked after in an intensive care unit and in the recovery room, both in close proximity to the operating rooms Nurses in these locations were particularly familiar with respiratory problems and their care Such a location also provided a more readily available source of anaesthetists and other medical personnel to diagnose and manage airway problems and other emergencies Standardization of equipment was distinctly advantageous in that the use of one type of respirator fostered familiarity with the technical aspects of respirator care

The control of the pulmonary infections referred to previously and the

FIGURE 1 Post-operative course after posterior fossa craniotomy with syndrome of "decay"

- A = Blood pressure (B P), systolic
- B = Heart rate (H R)
- C = Blood pressure, diastolic
- D = Rectal temperature
- E = Respiratory rate (R R)

The arrows indicate I M injection of 5 mg Aramine
Reflexes and responses as recorded by the attending nurses

early recognition of respiratory insufficiency were major problems. Diverse aspects in the control of pulmonary infection ranged from the design of rooms with adequate space to the design of respirators, from the management of patients to the education of nurses and attending medical staff. Education also contributed to the development of a greater awareness of respiratory insufficiency, resulting in a continuing increase in the use of intermittent positive pressure breathing during the past five years. This increase is reflected in the number of respirators required in the hospital: there are now twelve, and there were originally two. A still greater demand for respirator care is anticipated in the future.

SUMMARY

In a general hospital, 201 respirator cases have been managed by the Department of Anaesthesia. Although the over-all survival rate was 40 per cent, a classification based on the prognosis of the condition that caused the respiratory insufficiency showed that an 82 per cent survival rate was obtained in patients with a potentially favourable prognosis. Pulmonary infection was the main cause of death in this group, and measures to control contamination of the airway appeared to improve the patient's chance of survival. Patients with a potentially unfavourable prognosis had a very low survival rate (17 per cent) and the clinical observation of a terminal "decay syndrome" was of prognostic value.

Patients in whom the respiratory insufficiency was only one of many other derangements usually benefited at least temporarily from respirator treatment. Although the high mortality rate in this group (64 per cent) was only in part associated with respirator care, it could be lowered by the prevention of pulmonary infection.

It was thought that the control of infection and the prevention of contamination was a greater problem than the maintenance of adequate pulmonary ventilation in determining the success of respirator care. The avoidance of pulmonary infection together with the earlier recognition of respiratory insufficiency and the well-timed institution of respirator therapy could improve our results.

RESUMÉ

Dans un hôpital général, le Service d'anesthésie s'est occupé de 201 cas traités à l'aide de respirateurs. Bien que le taux de survie en général n'ait été que de 40 pour cent, une classification, basée sur le pronostic de la maladie qui avait causé l'insuffisance respiratoire, nous a démontré une survie de 82 pour cent chez les malades dont le pronostic était favorable. La principale cause de la mort dans ce groupe a été l'infection pulmonaire, et ce qui a amélioré la survie, ce sont les mesures prises pour contrôler la contamination des voies respiratoires. Les malades chez qui le pronostic était moins bon ont conservé un taux de survie très bas (17%), et l'observation clinique d'un syndrome de chachexie terminale nous a servi de valeur pronostique.

Les malades chez qui l'insuffisance respiratoire n'était qu'une pathologie parmi

plusieurs ont généralement bénéficié du traitement au respirateur, du moins temporairement. Bien que le taux élevé de mortalité dans ce groupe (64%) n'était associé qu'en partie aux soins d'un respirateur, il serait possible de l'améliorer par la prévention de l'infection pulmonaire.

Nous avons la conviction que le contrôle de l'infection et la prévention de la contamination nous ont posé de plus sérieux problèmes que le maintien d'une ventilation pulmonaire adéquate pour évaluer le succès des soins au respirateur. La prévention de l'infection pulmonaire aussi bien que le dépistage plus précoce de l'insuffisance respiratoire et l'installation bien minutée de la thérapie au respirateur pourraient améliorer nos résultats.

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