Papers and Originals

Four Years of Respiratory Intensive Care

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Each hospital community setting out to organize a system of progressive patient care, including an intensive care area, must attempt as a preliminary step to answer certain general questions. For example: How many beds out of the total available in the hospital will be required for intensive care of the most seriously ill patients? How long will these patients occupy the available beds? What will be the distribution of patients according to age? What mortality rate may be expected? In an attempt to answer these questions for the Glasgow Royal Infirmary a survey of patients in the hospital was carried out between July 1963 and January 1964. For the first three months the entire hospital population was assessed, and for the second three months the survey was confined to two general medical units and two general surgical units. This latter selective assessment made possible a closer scrutiny of the individual patients involved. In all, 280 patients were included, and the criteria for selection for the hypothetical intensive care area were taken to be: (*a*) if the patient required an individual nurse for any or all of the time, or (*b*) if any specific therapy requiring continual observation was necessary. The patients thus selected were arbitrarily classified according to whether the main problem was respiratory, cardiovascular, metabolic-biochemical, traumatic, etc.

Tables I and II give the results of the investigation in so far as age groups and bed occupancy were concerned. It was found that approximately 4% of the total bed complement

TABLE I.—*Distribution of Intensive Care Patients by Age Groups*

Report	Age Group (Years)								
	0–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90
Interim*	10	10	14	27	38	36	29	17	7
Final†	3	2	9	10	14	20	22	8	4

* Interim report represents a hospital-wide survey of three months' duration.
† Final report represents a three-months study of four selected units.

TABLE II.—*Distribution of Patients by Number of Days of Intensive Care*

Report	Duration of Intensive Care (Days)				
	1–2	3–5	6–10	11–20	Over 20
Interim	41	84	41	18	4
Final	19	42	19	9	3

of the hospital would be required for all intensive care purposes. For the Glasgow Royal Infirmary this would be about 40 beds.

The mortality in patients thought to require intensive care was found to be 19%. The overall hospital mortality during this six-month period was 4.2% for the first three months and 6.1% for the second three months.

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Respiratory Intensive Care Unit

Against this background of general data acquired from the prospective study, it is of interest to examine in detail the actual experience in one of the intensive care units in the Glasgow Royal Infirmary—namely, the respiratory intensive care unit. In October 1962 a "pilot" four-bed unit for the treatment of acute respiratory emergencies, both surgical and medical in origin, was opened. This unit was converted from a six-bed side-ward, and despite the reduction in bed numbers was far from ideal so far as floor space was concerned, and too small to enable isolation cubicles to be constructed.

This paper comprises an analysis and discussion of 488 patients treated over a period of four years. Table III summarizes these results, classifying the patients under the headings indicating the primary cause of the respiratory problem. The number of patients requiring temporary tracheal intubation or tracheostomy and mechanical assistance to ventilation are shown. The average length of stay in the intensive care unit for each group is also given.

TABLE III.—*Analysis of Patients Treated in the First Four Years in the Respiratory Intensive Care Unit*

Condition	Cases		Requiring E.T.T. or Tracheostomy		Requiring I.P.P.V.		Average Stay in Unit (Days)
	No.	%	No.	%	No.	%	
Traumatic ..	195	39·95	108	55·4	52	26·6	10·3
Post-operative	202	41·4	130	63·3	49	24·2	4·1
Drug poisoning	42	8·6	40	95·2	28	66·6	3·1
Obstructive lung disease	16	3·3	11	71·4	7	42·9	8·3
Miscellaneous	33	6·76	24	72·7	21	63·6	9·8
Total 1962–6	488	100	313	64·1	157	32·1	7·1

E.T.T.=Tracheal intubation. I.P.P.V.=Intermittent positive-pressure ventilation.

Traumatic Respiratory Problems

In Table IV the traumatic group of respiratory problems is divided into those patients suffering from the "crushed chest" syndrome (75 patients), multiple injuries with a respiratory/metabolic upset (73 patients), and severe head injuries requiring special measures to maintain a clear airway and adequate alveolar ventilation (47 patients). The overall survival rate in these severely ill patients was 58.9, the lowest

TABLE IV.—*Analysis of Traumatic Group of Respiratory Problems*

	Cases	Survivals
Chest injuries	75	53 (70·6%)
Multiple „	73	44 (60·3%)
Head „	47	18 (38·3%)
Total	195	115 (58·9%)

survival rate being in the grave head injuries. Those patients who suffered severe injuries to the thoracic cage and lungs presented the greatest challenge to the staff of the intensive care unit. This type of injury has in the past always carried a high mortality. The method of treatment employed in the Glasgow Royal Infirmary has been reported elsewhere (Reid and Baird, 1965 ; Campbell, 1966).

Postoperative Respiratory Problems

Those patients who presented with significant postoperative respiratory difficulties, whether following elective or emergency surgery, were treated in the intensive care unit. As there was a shortage of 24-hour recovery facilities, inevitably a proportion of the patients in this group were admitted to the respiratory unit only for short-term postoperative observation and therapy. Nevertheless, the average length of stay was 4.1 days for a total of 202 patients. Of these, some two-thirds required tracheal intubation or tracheostomy and one-quarter mechanical assistance to ventilation.

It is our experience that "relaxant problems" commonly arise from unrecognized disturbances of metabolism or cardiovascular or respiratory function. The other groups were determined by assessment of the patient's history and clinical examination as well as radiographic and electrocardiographic findings. In this series there were instances where it was difficult to determine whether an upset in acid–base balance actually preceded rather than followed a period of cardiovascular depression or respiratory insufficiency.

It may be noted that difficulties involving the relaxant group of drugs alone were uncommon in both elective and emergency cases, and all such patients survived in this series, requiring merely prolonged assistance to ventilation. Only three cases of true suxamethonium apnoea were identified in this series. The high incidence of pre-existing lung disease, as diagnosed on clinical, biochemical, and radiological evidence, is not surprising in the City of Glasgow. The higher survival rate in the elective cases is taken as a reflection of the better preoperative preparation of these patients and the ability to choose the optimal time during treatment for elective surgery.

Figs. 1 and 2 show the distribution of patients according to the site of operation, and indicate the comparative survival rates for the various procedures.

Two points arise with reference to the elective thoracic cases. Firstly, only a small percentage of the total number of admitted cases have had thoracic procedures, and these represent a minor fraction of the total performed in the hospital. Secondly, the higher survival rate compared with the elective upper abdominal procedures may reflect the fact that the thoracic cases are usually more extensively assessed, and the operation if performed is done under optimal conditions.

Drug Poisonings

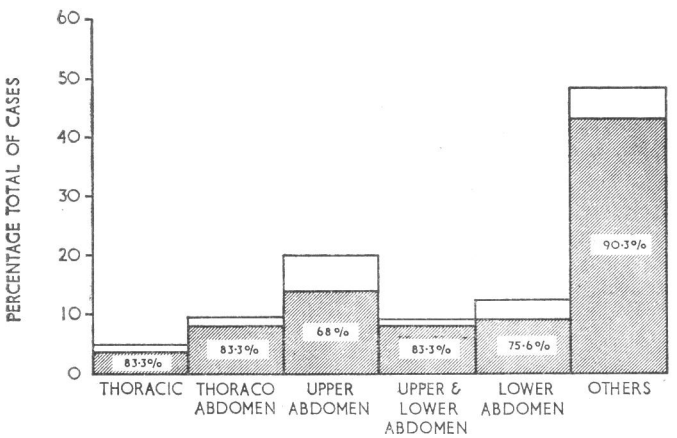
When respiratory failure complicates drug overdose, either accidental or self-administered, the patient is best treated in a respiratory intensive care unit working in close conjunction with a dialysis unit. Ideally, the two intensive care units should be adjacent, since more than one period of dialysis may be required, and this presents problems where the patient is still on intermittent positive-pressure ventilation. It is probably true to say that no patient need now die from the effects of barbiturate overdosage, since respiratory function can be supported almost indefinitely while forced diuresis or renal dialysis eliminates the drug. This view is supported by our experience of two remarkably high serum barbiturate levels successfully treated by this combined technique. One patient had an initial serum phenobarbitone level of 57 mg./100 ml. and the second had a serum butobarbitone level of 15 mg./100 ml. Both patients made a successful recovery (Kennedy *et al.*, 1967).

Nevertheless, only 37 patients out of 42 survived in this group, but those who died had already suffered prolonged severe hypoxia due to respiratory insufficiency before admission. Only two of these deaths were due to true barbiturate overdosage, the others being "mixed poisonings." Twenty-two of the patients were treated by forced diuresis and only three required artificial dialysis. No patient required a tracheostomy, endotracheal intubation with a cuffed tube being the method of choice at that time when an artificial airway was necessary (40 out of 42). The tracheal tube was not left in situ for longer than 72 hours in this group of patients, and their average stay in the unit was 3.1 days. Intermittent positive-pressure ventilation was necessary in 28 of the 42 patients.

Miscellaneous Cases of Respiratory Failure

Though this group of patients requiring respiratory intensive care is small in number, it comprises many of the most interesting and challenging types of respiratory disturbance. Table V details the individual conditions, and it can be seen that there is a variety of comparatively uncommon conditions represented here. The overall survival rate of 33.3% is low, but it must be remembered that only the most gravely ill patients with these conditions were admitted.

This miscellaneous group of patients averaged 9.8 days of treatment in the intensive care unit. A large proportion required tracheostomy (72.7%) and intermittent positive-



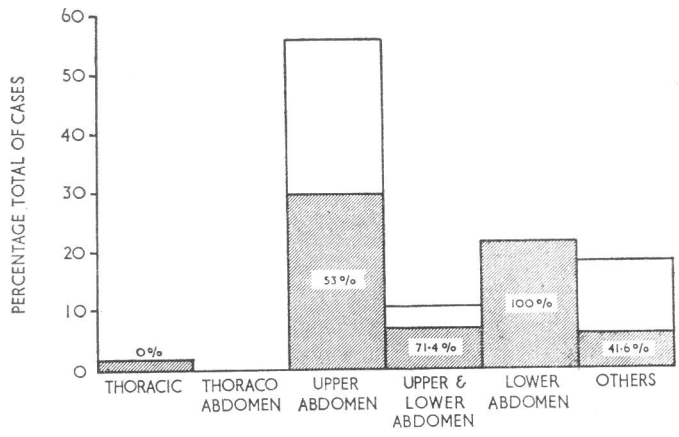


FIG. 1.—Analysis, according to site of operation, of 131 elective patients who developed postoperative respiratory insufficiency. The cross-hatched areas represent the percentage survival for each procedure. FIG. 2.—Analysis, according to the site of operation, of 71 emergency patients who developed postoperative respiratory insufficiency. The cross-hatched areas represent the percentage survival for each procedure.

pressure ventilation (63.6%). Tracheostomy was commoner than endotracheal intubation (20 out of 24 cases) mainly owing to the length of time required for treatment.

TABLE V.—*Variety of Conditions in Which Acute Respiratory Insufficiency Required Energetic Treatment. All Required Active Measures to Support Respiration In Addition to Specific Therapy*

Condition	No.
Accidental hypothermia	2
Cerebrovascular accident	7
Drowning	1
Myasthenia gravis	2
Myocardial infarctions with cardiac arrest	3
Myxoedema coma	2
Neurological and polyneuritis	7
Status eclampticus	1
Status epilepticus	4
Tetanus	2
Upper airway obstruction	2
	33

Obstructive Lung Disease

In the initial stages of the pilot respiratory intensive care unit those suffering from an acute exacerbation of chronic obstructive lung disease were admitted. Sixteen patients were treated during this period, 11 requiring intubation or tracheostomy and seven intermittent positive-pressure ventilation. These patients are now largely taken care of in a separate unit within the hospital, and this is highly desirable, since they tend to be an important source of infection and present a real hazard to the " clean " cases, particularly those in the traumatic group. If such patients are to be managed along with uninfected cases, there is no doubt that they should be isolated and if possible barrier nursed.

The standard treatment for this group of patients was controlled low oxygen therapy with the Edinburgh mask (Flenley *et al.*, 1963). Tracheal intubation was used rather than bronchoscopy to facilitate frequent and thorough aspiration of secretions. Tracheostomy was reserved as a last resort. Intensive physiotherapy is an essential part of treatment here, as indeed in all the patients treated in the intensive care unit, and this is combined with measures to stimulate coughing along with the appropriate antibiotic therapy.

Special Problems in Respiratory Intensive Care

Whatever the underlying cause leading to the episode of respiratory failure in an individual patient, certain common problems require consideration, and certain techniques have been evolved which are applicable to the treatment of all cases.

Cross-infection

Without doubt a major problem in a respiratory intensive care unit is the control of infection and the segregation of known infected cases. In the small four-bed unit the infection rate was high, and all tracheostomies became technically infected as judged by serial culture of tracheal swabs, though this did not necessarily result in intrapulmonary infection. In addition, a large number of these patients required indwelling urinary catheters, and, despite aseptic precautions, bladder infections were inevitable in most long-stay cases. The close juxtapositioning of the four beds, approximately 5 ft. (1.5 m.) apart side to side and 6 ft. (1.8 m.) apart end to end, defeated the most stringent aseptic precautions in the handling of tracheostomies. Again there was no provision for ventilation of the ward with filtered air, and the mechanical ventilators were not able to be adequately sterilized for the first two years. The main infecting organism was the resistant *Staphylococcus aureus*, but when this was eliminated by use of the newer potent antibiotics a secondary invasion with *Escherichia coli, Proteus mirabilis, or Pseudomonas pyocyanea* was common. The lack of cubicles prevented barrier nursing of known infected cases, and resulted in a further increase in the infection rate. On those occasions when the infection rate reached epidemic proportions the unit was closed for thorough cleansing, including washing of walls from floor to ceiling.

Since early 1966 a new respiratory intensive care unit has been in use which represents a great advance, particularly from the point of view of control of infection. Fig. 3 shows the plan of this eight-bed unit, which is a conversion from a 26-bed Nightingale ward. Two large cubicles (dimensions 15 by 12 ft.; 4.6 by 3.7 m.) are available for the barrier nursing of selected cases, both patients known to be infected and those potentially infected—for example, those with superficial burns. In addition, the whole unit is ventilated with filtered warmed air by a plenum system with extractor fans at each bed station. Humidity of the air is also controlled. One cubicle can be separated from the plenum system and the atmosphere independently controlled by means of a standard office-type air-conditioning unit. The main advantage, however, in this new unit is that the beds are widely set apart in individual bays. Each bed station has its *own* trolley with all its *own* instruments—for example, Wright's respirometer and laryngoscope. No equipment or instrument is permitted to be transferred from one bed station to another. Entry to the unit is controlled by means of an interchange area, and all persons visiting the unit are required to wear gown, mask, and overboots. Such cases of known infection as have been admitted

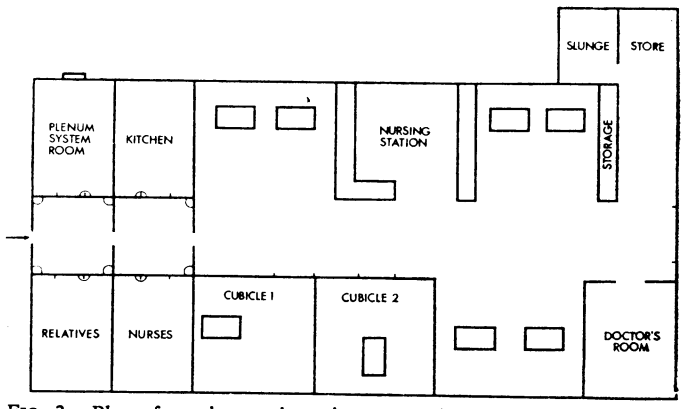


FIG. 3.—Plan of respiratory intensive care unit. The interchange area lies between the inner doors opposite the kitchen and nurses' staff-room. The laboratory, which is adjacent to but outside the unit, is not shown.

of necessity have been nursed in the cubicles without any evidence of cross-infection. The practice is for every patient to be swabbed (nasopharynx or trachea and skin) and a urine culture done at the time of admission. This latter test is repeated, if the patient is catheterized, at least twice weekly throughout the patient's stay. All staff have regular nasopharyngeal swabs taken.

A further advance in the control of infection has been in the sterilizing of the ventilators. These are now sterilized with ethylene oxide, after thorough cleansing, before being reused (Bishop *et al.*, 1962). In long-term cases these machines should be changed every three to four days. Currently an investigation is being carried out into the advantages of bacterial filters on the ventilators. A record is kept of the bacteriological history of each machine and its associated parts—for example, spirometer and humidifier—in order to facilitate tracing the source of any outbreak of pulmonary infection.

Oxygen Therapy

Controlled oxygen therapy is an important part of treatment in these patients. Control implies measurement, and this consists of regular oximetry to monitor the inspired oxygen concentration by means of the Beckman instrument. In addition, blood gases are measured at frequent intervals in all

acutely ill patients as a guide to the efficiency of treatment. This demands a "bedside" service, and the medical staff in the unit are all trained in the use of the appropriate apparatus to measure haemoglobin oxygen saturation, arterial oxygen tension, arterial carbon dioxide tension, acid–base state, and haemoglobin in the laboratory adjacent to the unit.

In addition to its function as originally described for administering controlled low-oxygen concentrations, the Edinburgh mask is also used, with the modification described by Campbell (1967), to administer inspired concentrations up to approximately 80%. The advantage of this system is that one basic disposable mask can be used for all types of oxygen therapy.

Metabolic Care and Nutrition

Intensive care demands a great deal of assistance from the biochemist. The measurement and restoration to normal of blood volume, hydration, and electrolyte levels are well understood.

One feature of patient care which often suffers neglect is the provision of an adequate nutritional regimen. This aspect of the care of the surgical patient is well described by Moore (1959). It applies to all patients, particularly those in an intensive care unit (Peaston, 1967).

The importance of adequate nutrition cannot be overstressed, since many of these patients suffer a severe catabolic response after injury or surgery, and this may be aggravated by concomitant infection when the calorific requirement may reach 4,000 calories a day. If muscle wasting is allowed to develop then "weaning" from the ventilator may be prolonged, despite a return to normal pulmonary function, since the patient is unable to perform the required work of respiration. The condition of such a patient can resemble that of a severe myasthenic.

Central Venous Pressure

The measurement of central venous pressure in the surgical patient (Sykes, 1963) is of value where there has been severe blood loss. A catheter can be introduced into the superior vena cava via the external jugular or an antecubital vein, but if this is impracticable a saphenous cut-down at the groin enables a wide-bore catheter to be introduced into the inferior vena cava. The presence of a caval cannula also enables parenteral feeding to be instituted at an early stage in treatment without the complications of peripheral venous thrombosis.

Monitoring of Vital Functions

It has been found invaluable to make use of a central monitoring system whereby E.C.G., heart rate, temperature, and respiratory rate can be observed continuously in every patient. The recording of these functions can be carried out even by a nursing-aide, thus enabling the more skilled nursing staff to carry out the heavy demands of patient care. Blood pressure is, in our experience, still best measured by the mercury sphygmomanometer at the bedside and only in special cases via an indwelling arterial cannula. Respiratory measurements carried out by the nurse include minute volume, airway pressure, and respiratory frequency when on intermittent positive-pressure ventilation, and respiratory frequency and minute volume when breathing spontaneously. Regular auscultation of both lung fields is also carried out by the nursing staff to detect any gross changes in air entry.

Intelligent use of modern technological aids can to some extent mitigate the shortage of skilled nursing personnel, though it must be remembered that monitoring devices are only an extension of the nurse's own senses and not in any way a substitute for acute observation and constant attention at the bedside.

Organization and Staffing

The Glasgow Royal Infirmary respiratory intensive care unit not only serves the parent hospital but also provides a group service for the associated hospitals. Some 5% of cases, a figure which is increasing, come from other hospitals throughout the Western Region, and a small number are referred from hospitals outside this region. This intensive care unit is associated with other intensive care areas within the hospital —namely, the renal dialysis, cardiovascular-surgical, acute coronary, and medical respiratory units.

Medical Staff

The unit is administered by the department of anaesthetics. Three consultant anaesthetists share the senior duties on a sessional basis. Two anaesthetic registrars are in training at any one time, each for a period of two months, with no other duties. An anaesthetist is always on duty *in* the unit, where simple sleeping accommodation is provided. The medical staff are also responsible for the anaesthetic side of the hospital emergency resuscitation and cardiac arrest service, which is on a "crash call" basis. This ensures that experienced anaesthetic assistance is immediately available in appropriate cases. The importance of the integration of such an emergency service within the organization of the intensive care unit has been mentioned by Campbell (1965).

Ward rounds, at least four in a 24-hour period, are conducted by the consultant anaesthetist on duty. That is, apart from a primary concern with the patient's respiratory problem, the consultant is responsible for overall care. Administrative responsibility for the running of the unit cannot readily be separated from a clinical responsibility to the patients. Joint bedside examination and discussion of each case, if necessary several times throughout the 24 hours, is essential to full co-operation between the various specialists involved in the treatment of an individual patient. As a consequence, treatment is under continual review, continuity of care progressing from the intensive care unit to the general ward. This co-operative effort has been a most successful and rewarding feature of this work, and the advantages of the system have been stressed by Kennedy *et al.* (1963).

Nursing and Ancillary Staff

While the ideal number of trained nursing staff per patient has been variously estimated at from one to two per patient per shift (Nolan, 1965), the following staffing has been found adequate for most of the time in this respiratory unit: four sisters, two full-time and three part-time staff nurses, and two trained nurses assigned to the unit while on postgraduate intensive care training course; two student nurses; three full-time and two part-time State-enrolled nurses; two male orderly-technicians and one female orderly; one housekeeper; and one domestic.

An eight-hour shift system is not possible with these numbers and a "partial" shift system is operated. The working day is from 8 a.m. until 9 p.m., and night from 9 p.m. to 8 a.m., and this arrangement has not led to any lack of continuity in care. There is no doubt that, taking into consideration the demanding nature of the work, a two-day rest period a week is essential. Great use is made of ancillary nursing staff, who can all be employed in such a way that trained staff are relieved of the simpler but necessary non-nursing duties.

The contribution made by the physiotherapy staff deserves special mention. Their services have proved invaluable, and they are required throughout the 24 hours. Indeed, all

supporting services, laboratory and diagnostic, must be on a 24-hour seven-day week basis.

Despite the physically and mentally exhausting nature of the work morale is high. This is thought to be largely attributable to the fact that medical and nursing staff have been to some extent self-selective. In addition, there is the fullest discussion of all problems, theoretical and practical, between medical, nursing, and ancillary staff. This is carried out both at the bedside and in the form of lecture-tutorials. Finally, despite the high mortality rate, the successes have been such that no member of the staff requires any further demonstration of the value of the concept of intensive care for patients with acute respiratory difficulties.

Summary

It is suggested that an essential preliminary to the setting up of a new intensive care unit is the conducting of a preliminary survey of the hospital population to determine the likely number of patients requiring this degree of care. Such a prospective study, carried out in the Glasgow Royal Infirmary, to assess the total requirements for intensive care is described. The next step, which may be carried out simultaneously, is to set up a small "pilot" unit in which actual experience may be gained of the problems of organization and care of patients. The final phase, if indicated, is the establishing of a definitive unit for the intensive care of one or other group of patients—for example, respiratory problems, acute coronary cases, renal problems, etc.

The results of the intensive care of 488 patients with acute respiratory problems are presented. Certain aspects of organization and patient care involved in the treatment of these cases are discussed.

We should like to pay tribute to our colleagues of the medical and nursing staff of the Glasgow Royal Infirmary, whose co-operation, interest, and hard work have made the success of the respiratory intensive care unit possible. In particular we are deeply indebted to the staff of the Department of Physiotherapy for their invaluable contribution to patient care. We are grateful to the members of the committee who carried out the original prospective study on intensive care needs in the hospital, and the Board of Management of Glasgow Royal Infirmary for permission to publish the results given in Tables I and II.

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Visuo-motor Disability in Schoolchildren

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In a recent study the visuo-motor abilities of 810 schoolchildren (427 boys and 383 girls) aged 8–9 years were sampled by means of a new group test-battery. This comprised 11 tests designed to explore various aspects of visuo-motor capacity and to provide norms for the assessment of disability. The tests used could be classified under three general headings: (1) dexterity—for example, use of scissors and simple pencil control within guiding lines; (2) perceptual analysis—for example, the capacity to discriminate overlapping designs or to isolate figures "embedded" in more complex designs; and (3) constructional skill, as evidenced in block design, drawing, and other simple constructional tasks. Full details of the tasks and the principal findings are available elsewhere (Brenner and Gillman, 1966). In addition, verbal intelligence was measured with the standard National Foundation for Educational Research Verbal Test I. All testing was carried out by two of us (M. W. B. and S. G.).

A high correlation was found between scores on the visuo-motor test-battery and verbal I.Q. However, the inquiry brought to light 54 children (6.7%) with I.Q. above 90 whose scores on the visuo-motor test-battery deviated more than 1 S.D. from the means established for their I.Q. groups. The performance of these 54 children, who were equally divided between boys and girls, was so poor as to suggest a specific developmental disability. Despite the fact that verbal intelligence was in no case below 90 (and not infrequently above 110), school performance was in general found to be poor, especially in regard to spelling, writing, and arithmetic—though reading was as a rule adequate. The characteristic most frequently remarked on in these children was *clumsiness* in gait, in movement, or in fine motor control. Untidy, careless, and slovenly school work was constantly reported.

In the 31 most seriously affected children the visuo-motor test scores deviated 2 S.D. or more from the mean. Fourteen children in this group who were still resident in the area and who remained available for continued follow-up study over a three-year period form the subject of the present report. Each of these children was matched for age, sex, handedness, verbal I.Q., and home and school background with a child drawn from the same sample who had shown no appreciable discrepancy between verbal I.Q. and the score on the visuo-motor test-battery. The children in both groups, which are termed the experimental and control groups, were retested one year after the initial examination, and their progress at school was followed for two further years. Information regarding previous history was obtained from parents, supplemented in some cases by reports from general practitioners. In interviews with parents and teachers, semi-standard forms of questionary were used, and no information was given on whether a particular child had been assigned to the experimental or the control group. All test data were scored by at least two of us independently.

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