INHALATION THERAPY

A METHOD FOR THE COLLECTION AND ANALYSIS OF STATISTICS *

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To evaluate comprehensively any clinical practice in medicine, case records available for statistical analysis are essential. The evaluation of inhalation therapy is no exception to this principle. Depending on recollection may lead one far from the truth. To satisfy the need for such records, the method herein discussed is recommended.

A statistical plan for evaluating any form of therapeusis should include as an integral part of the study the many variables which may have a bearing on the result. To satisfy statistical requirements, the data from a large series of cases should be collected and studied. The presence of many variables in such a series makes it necessary, for reasons of time, to employ a mechanical method such as the Hollerith.

This system is widely employed in the statistical evaluation of anesthetic and surgical morbidity, in accordance with recommendations of the Committee on Records of the American Society of Anesthetists. In this method the coded variables are recorded on a card by punch holes and sorting is done mechanically at the rate of 400 cards a minute. Those who have employed or are familiar with the punch-card method should have no difficulty with its details for the study of inhalation therapy.

The factors considered, arranged in the fields they occupy in the Hollerith card, are presented in figure 1. The first six fields, Geographic, Case number, Month, Year, Age and Sex and their coded variables, are identical with those in the anesthesia code. The Geographic field is of value in this study as in the other, since it allows the pooling of cards, their study as a group and final segregation and return to their source. The need to include case number, month, year, age and sex is obvious. The inclusion of the case number makes more accessible the original case record for reference. The four other variables may have a bearing on the incidence of the condition treated, the type of treatment employed, or the end result.

Diagnosis occupies a three-column field permitting 999 diagnoses or subdivisions of diagnoses to be included. The list of variables considered under this field is like that in the anesthesia code except for addi-

* Read before a meeting of the American Society of Anesthetists, New York City, Feb. 10, 1944.

tional diagnoses or conditions which are necessary in a study of this particular therapy.

The field Indications also occupies three columns. Accuracy demands that the indication for inhalation therapy as well as the diagnosis be stated, for the former is not always obvious from the latter. For example, the diagnosis may be peritonitis. Inhalation therapy may have

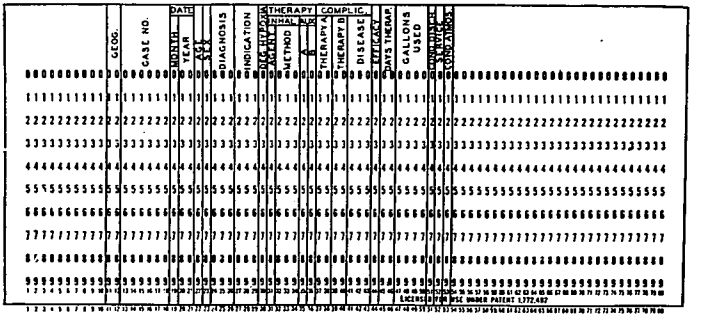

FIGURE 1.

been instituted for the treatment of either the associated toxemia, hyperpyrexia or intestinal distention. For statistical purposes such conditions as these must be considered if one is to arrive at a reasonable conclusion as to the efficacy of inhalation therapy. In this field an attempt has been made to form groups in such a way that the etiologic factor of the hypoxic states may be evaluated. For example, respiratory obstruction may be diagnosed, but for statistical purposes it is important to know the site and cause of the obstruction. It is the field of Indications that must undergo the most minute statistical breakdown and study. Since the variables in this group may have to be broken down and studied in small groups, they were first divided into Hypoxic and Nonhypoxic states (table 1).

TABLE 1

FIELD 8 INDICATIONS

A. Hypoxic States
  1. Atmospheric Hypoxia
  2. Tidal Hypoxia
    Central, Disease
    Central, Drug
    Obstruction
    Altered Mechanism
  3. Alveolar Hypoxia
  4. Hemoglobic Hypoxia
  5. Demand Hypoxia
  6. Stagnant Hypoxia
  7. Histotoxic Hypoxia

B. Non-Hypoxic States
  8. Changes in atmosph. press.
  9. Nitrogen Removal
  0. Miscellaneous

The hypoxic states were further subdivided into seven groups depending on the mechanism of production. They are Atmospheric,

Tidal, Alveolar, Hemoglobic, Demand, Stagnant and Histotoxic. Atmospheric, tidal and alveolar hypoxia are the forms of oxygen lack commonly considered under anoxic anoxia.

Atmospheric hypoxia is a state of oxygen lack in tissue due to a decrease in the partial pressure of oxygen in the respired atmosphere to less than 155 mm. of mercury (that of room air at sea level). Table 2 gives those conditions which may cause atmospheric hypoxia and the code numbers assigned to them.

TABLE 2

HYPOXIC STATES

1. Atmospheric Hypoxia

101 High altitudes
111 Anesthetic atmospheres
121 Unventilated spaces
149 Others

Tidal hypoxia is a condition of oxygen depletion which results from decreased respiratory volume (table 3). This form of hypoxia is further subdivided as to the mechanism of production. A decrease in tidal exchange may be the result of disease, trauma, the action of drugs or a combination of these factors.

TABLE 3

HYPOXIC STATES

2. Tidal Hypoxia

Central-Disease
201 Cerebral lesions—tumor, abscess, edema
202 Meningitis, encephalitis
203 Medullary paralysis, polio.
204 Asphyxia Neonatorum (traumatic extraction)
209 Others

Central-Drugs (not used as anesthetics)
210 Morphine
211 Barbiturates
212 Combinations of above
214 Asphyxia Neonatorum (narcotic)
219 Others

Central-Drugs (used as anesthetics)
220 Morphine
221 Barbiturates
222 Tribromethanol
223 Ether
224 Cyclopropane
225 Chloroform
226 Ethyl Chloride
227 Vinyl Ether
228 Paraldehyde
229 Comb. of anesthetics
234 Asphyxia Neonatorum (anesthetic)
239 Others

Central-Mixed etiology
2X4 Asphyxia Neonatorum

Three varieties of hypoxia caused by drugs have been distinguished: when the drug is used as an anesthetic agent, when it is employed for other purposes, and when it is used for both reasons.

Tidal hypoxia may be the result of a decreased respiratory volume due to obstruction (table 4). The variables are grouped and coded according to the site and etiology of the obstruction. An altered respira-

TABLE 4

HYPOXIC STATES

2. Tidal Hypoxia

Obstruction-pharyngeal
- 241 Tumor, foreign body, mucus
- 242 Edema, abscess
- 243 Relaxed Muscles
- 249 Others

Obstruction-laryngeal
- 251 Tumor, foreign body mucus
- 252 Edema, abscess
- 253 Cord adduction
- 254 Cord adduction, postop.
- 259 Others

Obstruction-tracheal
- 261 Tumor, foreign body, mucus
- 262 Edema, abscess
- 263 Compression, collapse
- 264 Compression, collapse, postop.
- 269 Others

Obstruction-bronchial
- 271 Tumor, foreign body, mucus
- 272 Edema, abscess
- 275 Asthma
- 279 Others
- 2XX Drowning

tory mechanism may also be the cause of tidal hypoxia (table 5). Here the decreased respiratory exchange is the result of a change in respiratory dynamics.

TABLE 5

HYPOXIC STATES

2. Tidal Hypoxia

Altered mechanism
- 280 Convulsions, disease
- 281 Convulsions, drug
- 282 Emphysema
- 283 Shifting mediastinum
- 284 Paradoxical respiration
- 285 Intercostal paralysis, disease
- 286 Intercost. paralysis, spinal anesth.
- 287 Complete respiratory paral. sp. anesth.
- 289 Others

- 291 Positional
- 292 Appliances and restraints
- 299 Others

Alveolar hypoxia is that state of oxygen starvation due to a decrease in the number or the efficiency of functioning alveoli (table 6). Here, also, the variables are grouped according to the cause of the hypoxia. This may be the result of involvement of the alveoli by such a process as pneumonia, compression of the alveoli by atelectasis or pleural effusion or a decreased alveolar efficiency such as may be caused by intrapulmonary exudate.

Combinations of types of hypoxia undoubtedly will occur. This will be true particularly of the alveolar and tidal forms. For the purposes of this statistical code, numbers will be assigned to these combinations. When mixed forms of hypoxia are to be coded, the assigned numbers should of course be employed.

TABLE 6

HYPOXIC STATES

3. Alveolar Hypoxia

301 Pneumonia, lobar	321 Pneumothorax
302 Pneumonia, broncho.	322 Hydrothorax
303 Pneumonia, T. B.	323 Hematothorax
	324 Pyothorax
311 Atelectasis	325 Diaphragmatic hernia

329 Other compression as packs etc.

331 Pulmonary edema, toxic gases
332 Pulmonary edema, cardiac in origin

The term hemoglobic hypoxia is a substitute for the term anemic anoxia. Conditions which may produce oxygen hunger because of an insufficient amount of hemoglobin available to carry oxygen are listed with their code numbers in table 7.

TABLE 7

HYPOXIC STATES

4. Hemoglobic Hypoxia

411 Blood loss, acute
412 Blood loss, chronic
413 Red cell destruction, poisons
414 Red cell destruction, disease

421 Reduced available hgbn., CO poisoning
422 Reduced available hgbn., Sulfa poisoning

431 Decreased production red blood cells

449 Others

Under demand hypoxia (table 8) are included those metabolic conditions in which the bodily requirements for oxygen are elevated above normal.

TABLE 8

HYPOXIC STATES

5. Demand Hypoxia	6. Stagnant Hypoxia
501 Hyperthyroidism	611 Circulatory failure
502 Hyperthyroid., postop.	612 Circ. failure, postop.
	613 Circ. failure with hemorr.
511 Hyperpyrexia, disease	614 Circ. fail. with hemorr. postop.
512 Hyperpyrex., artif. induced	
	621 Coronary heart disease
521 Blood dyscrasias	
	649 Others
549 Others	

7. Histotoxic Hypoxia

701 Cyanide poisoning

The oxygen lack in tissue resulting from inefficient circulation is termed stagnant hypoxia.

Histotoxic hypoxia is the inability of the cells to utilize oxygen properly.

Nonhypoxic states which may require inhalation therapy are divided into three groups—changes in atmospheric pressure, nitrogen removal, and miscellaneous (table 9).

TABLE 9

NON-HYPOXIC STATES

8. Changes in atmospheric pressure
- 801 Foll. increased atmos. pressure
- 802 Foll. decreased atmos. pressure
- 803 Foll. increased oxygen tension
- 811 Prev. increased atmos. pressure
- 812 Prev. decreased atmos. pressure
- 821 During increased atmos. pressure
- 839 Others

0. Miscellaneous
- 001 Angina Pectoris
- 011 Migraine
- 021 Tracheitis
- 022 Bronchitis
- 030 Burns (unassoc. with stagnant hypoxia)
- 040 Hiccough
- 099 Others

9. Nitrogen Removal
- 901 Intestinal distention
- 911 Subcutaneous emphysema
- 921 Postencephalography

The efficacy of inhalation therapy often depends on the degree of hypoxia for which the patient is being treated. For this reason, hypoxia has been divided into degrees of severity. It is hoped that the classification of the signs and symptoms into grades will have the same advantages as the classification of physical state, which has a very important role in the anesthesia study (above mentioned). This grading of hypoxia, if carefully studied and followed, will introduce into thought,

TABLE 10

FIELD 9. GRADE OF HYPOXIA

Hypoxia, Grade I

Over-confidence, restlessness, nausea, headache, impaired judgment, impaired vision, dizziness, weakness, increased respiratory rate, increased pulse rate.

Hypoxia, Grade II

Vomiting, anxiety, muscle incoordination, twitching, elevated temperature, mental confusion, marked increase in respiratory rate, rise in blood pressure, air hunger, cyanosis.*

Hypoxia, Grade III

Unconsciousness, convulsions, slow, full and bounding pulse, slowing respiration, irregular respiration, fall in blood pressure, cyanosis.*

Hypoxia, Grade IV

Coma, respiratory arrest, circulatory collapse, asphyxia pallida.

* The presence of cyanosis is dependent upon the amount of hemoglobin, type of skin, and the condition of the peripheral circulation.

speech and writing a common basis of understanding of this highly varied clinical condition. The suggested classification is presented in table 10. It may be noted that Grade I hypoxia is only a moderately well-compensated oxygen lack. The inhalation of oxygen may nevertheless be of value before the patient is so classified. An individual may be satisfying his tissues' demands for oxygen by some compensatory mechanism such as hyperpnea. The hyperpnea of itself may be taxing his powers of reserve and may soon fail. It is thus important that inhalation therapy be instituted before the patient begins to show evidence of entering into Grade I hypoxia.

The agents which are employed in inhalation therapy—oxygen, helium-oxygen and carbon dioxide—are listed with their code numbers in table 11. There is room for any additional agents that may come into use.

TABLE 11

FIELD 10. AGENT

1. Oxygen
2. Helium Oxygen
3. Carbon Dioxide
8. Combinations
9. Others

For the purposes of coding and the subgrouping that is necessary for statistical analysis, it is important that the methods employed be grouped with complete disregard of the names either of the manufacturer of the apparatus that is used or of the name of the individual who may have developed it. This is no less true here than it was with the names attached to anesthetic procedures, the terminology of which was

TABLE 12

FIELD 11. METHOD

Column 1. (Apparatus)
1. Room, chamber
2. Tent, body
3. Tent, head
4. Mask, face
5. Mask, nasal
6. Open, spray, cone
7. Other rebreath. device
8. Insuffl. oropharyngeal
9. Insuffl. endotracheal
0. Automatic mechan. body respirator
X. Manual artificial respiration
Y. Combination, others

Column 2. (Carbon Dioxide)
1. CO_2 accum. or rebreathing
4. CO_2 absorp. To and Fro
5. CO_2 absorp. Circuit
7. No CO_2 accum. acct. flow
8. No CO_2 accum. acct. valves
0. No problem

Column 3. (Pressure)
1. Atmospheric
2. Intermittent negative
3. Constant negative
6. Intermittent positive
7. Constant positive
8. Alternating pos. and neg.

based either on the apparatus employed or the name of an individual attached to the particular anesthetic procedure. The use of proper names leads to confusion. This is apparent when one considers two methods of therapy in common use which are employed interchangeably and which are distinguished by name only. Two appliances, the B.L.B. mask and the O.E.M. mask, have important functional differences. It is also true that a single piece of equipment may function in several different ways; for example, a gas machine. When a gas machine is used for inhalation therapy, carbon dioxide may accumulate or it may be removed from the respired air. Positive pressure may be employed during inspiration or during the entire respiratory cycle. The methods of inhalation therapy may vary so greatly that each merits a terminological consideration by itself.

The code covering "method" (table 12) occupies three columns, each of which covers an important variable. By this means the method can be exactly described. A three-column code is used. Each of the three columns denotes a prime consideration. They are as follows:

1. The mechanism by which inhalation therapy is administered; that is, mask, catheter or tent.
2. The presence or absence of carbon dioxide in the respired atmosphere because of administration, accumulation or removal.
3. The use of negative, atmospheric, positive or differential pressures.

By employing three-digit combinations one is able to code any method of inhalation therapy in current use. There is sufficient elasticity to add any method which may be introduced in this form of therapy. Some of the common methods with their code numbers are submitted in table 13.

TABLE 13

CODE NUMBERS FOR COMMON METHODS

Oropharyngeal Insufflation	871
Tent—CO_2 Absorption	251
Tent—CO_2 Accumulation	211
Burgess Open Top	311
B.L.B. Oronasal Mask	411
O.E.M. Oronasal Meter Mask	481
O.E.M. Oronasal Meter Mask Positive Pressure	486
Kreiselman	486
Drinker	002
Emerson	488

The results of inhalation therapy may be dependent in large part on some form of auxiliary therapy. Such therapeutic procedures must be included in a statistical system such as this (table 14). Two fields are available to note such treatment so that two types of auxiliary therapy may be coded. They are then available for statistical evaluation.

TABLE 14

FIELD 12. AUXILIARY TREATMENT

0. None
1. Nasopharyngeal airway
2. Oropharyngeal airway
3. Tracheal airway
6. Pharyngeal Aspiration
7. Tracheobronchial toilet
8. Combination of above
9. Others

Inhalation therapy exposes the patient to hazards. Their occurrence should be noted. A list of complications is presented in table 15. Compilation and study of this field may reveal the cause of the occasional failure of inhalation therapy to produce the desired results. The presence or absence of complications to the disease under treatment must be considered. The code for these is the same as that under diagnosis. A statistical study of the relationship between inhalation therapy and complications to the disease may be of great value.

TABLE 15

FIELD 13. COMPLIC. TO INHAL. THERAPY

01 Rubber sensitivity
11 Claustrophobia
12 Uncooperative
13 Delirium
14 Fire, explosion
31 Sore throat
32 Epistaxis
33 Trauma, other
41 Poor funct. delivery apparatus
42 Leaks
43 Unsatisfact. concent.

TABLE 16

FIELD 15. EFFICACY

0. No Value
1. Could not determine
2. Beneficial
3. Deleterious
9. Not noted

The efficacy of inhalation therapy is to be coded. The code for these variables is listed in table 16. The duration of treatment in days may be recorded. It is possible to note any period in days up to 99. Gallons of gas used may be noted in hundreds up to 9,999. The coded variables for condition on discharge from hospital are listed in table 17. A

TABLE 17

FIELD 18. CONDITION ON DISCH.

1. Well
2. Improved
3. Unimproved
4. Dead of condition causing hypoxia
5. Dead of intercurrent complication

standard code for the "service" on which the patient is treated is not possible. This would vary with the institution. The list as employed at one institution * is presented in table 18.

It seemed desirable to include the possible use of conditioned atmospheres as part of the inhalation-therapy code. This field is the last of

RHODE ISLAND HOSPITAL
INHALATION THERAPY STUDY CHART

	Hospital No.	364086
Name John Jones Ward C	1. Geographic No.	1 2
Diagnosis Peritonitis Diffuse 4 days post appendectomy	2. Case No.	0 0 1 3 4 6
	3, 4. Date March 4,1943	3 4 3
	5, 6. Age 62 Sex M	7 1
	7. Diagnosis	5 0 7
Indication Paralytic ileus Distention marked	8. Indication	9 0 1
	9. Degree Hypoxia None	0
10. Agent Oxygen		1
11. Method Burgess Closed Top CO2 Absorption		3 5 1
12. Auxiliary Treatment None		0 0
13. Complications to Inhalation Therapy Uncooperative		1 2 0 0
14. Complication to Disease None		0 0 0
Remarks Ileus moderately relieved within 24 hours. Well relieved at end of 36.	15. Efficacy Beneficial	2
	16. Duration, Treatment, Days	0 4
	17. Gal. used. Hundreds	X X X X
	18. Condition on Discharge Improved	2
	19. Service 1st. Surgical	1
	20. Conditioned Atmosphere None	0

FIGURE 2.

the variables considered and may be omitted if not desired. For those who may wish to include this aspect, the conditioned atmospheres and their code numbers are listed in table 19.

The manner in which the data are collected will be governed by the individual preference of those who use this statistical method. It seems wise to present the method one of us (M. S.) employs. A specially drawn up form is placed upon the patient's chart when inhalation ther-

* Rhode Island Hospital, Providence, Rhode Island.

TABLE 18

CODE NUMBERS FOR SERVICE

Rhode Island Hospital

1. 1st Surgical	7. Eye
2. 2nd Surgical	8. Nose & Throat
3. Genito-urinary	9. Medical
4. Gynecological	0. Children
5. Fracture	X. Others
6. Orthopedic	Y. Neuro-Surgical

TABLE 19

FIELD 20. CONDITIONED ATMOSPHERE

0. None	
1. Heat to 110–120° F.	5. Cold to 70–50° F.
2. 100–110° F.	6. 50–40° F.
3. 90–100° F.	7. 40–20° F.
8. Pollen filtration	9. Humdification

apy is started (fig. 2). Upon this chart are immediately placed in words and in code the variables as they present themselves. The form remains with the patient's chart until after discharge from the hospital. The forms are then collected and filed until such time as punching and analysis may be desired.

SUMMARY

A method for the collection of statistics for inhalation therapy is presented. The variables considered and a tentative code to cover them are submitted. A form already in use for the inclusion of all the data necessary for final punching upon a Hollerith card is presented.

The members of the committee wish to express their thanks for the valuable assistance rendered in the creation of the code and in an experimental run to Drs. Elihu Saklad and Priscilla Sellman and to Ballard Smith, Gordon Garnett, William Russell and Robert Charn.
