THE CHICAGO KEYSORT ANESTHESIA RECORD

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Biometry, the science of medical statistics, is badly handicapped where
the old "paper-and-pencil" methods are used. So many interrelated
facts are involved in biological studies that important ones are often
ignored as the compilations become too complex. Many of our old
ideas have changed since more efficient analysis of clinical data has
become possible. For example, there is now less emphasis in anes-
thesiology on drugs as etiological factors in postoperative complica-
tions. This is a direct result of more complete studies of the role
played by the operation and the condition of the patient, and made
possible by the existence of mechanical methods of sorting data.

A few years ago, Tovell (1) and Rovenstine (2) reported the adapta-
tion of the Hollerith punch-card to anesthesia records. However, con-
siderable preliminary work is required with this method before the
record can be placed in the I.B.M. machine for sorting. The necessary
equipment is expensive to rent, and not readily available at all times to
those actually compiling the statistics. Yet, frequent assessment of
clinical data is particularly desirable in an anesthesiology department
that trains residents or is responsible for student teaching. Only
in this way can more impressions be verified or repudiated. Beginners
must be provided with facts to counteract the many unsubstantiated
opinions they will hear later in their medical careers.

To encourage more anesthesiologists to use their present excellent
records to accumulate reliable statistics, a simple sorting method must
be provided—one that can be used with efficiency and economy under
any circumstances.

In 1943, Nosworthy (3) brought out a small record card which
combined both the clinical anesthesia chart and means for sorting the
data on it. In America, this is known as a "Keysort Card", and the
Chicago Anesthesia Record is a direct outgrowth of the English one.
We desired a more elaborate graph, more space for accessory data,
and "checkoff" pre-and post-operative records. Our card is the same
size as an ordinary anesthesia chart, which gives us the uncrowded

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space we need and still leaves room around the borders of the card for the sorting mechanism.

Sorting of Keysort cards is based on a very simple idea. Around the edge of the card are one or two rows of holes, centered about \( \frac{1}{8} \) inch and \( \frac{3}{8} \) inch from the edge. These holes are grouped under related headings. For example, 14 holes along the lower edge of our card are for recording the anesthetic agent. If cyclopropane is used, the
edge of the card is punch-cut so that the hole opposite the word “cyclopropane” now connects with the edge of the card. (fig. 1). Then, if a group of cards is stacked up evenly, and a needle is passed through the hole representing cyclopropane, the needle can be lifted to carry away those cards not punched, leaving behind those with the “cyclopropane” hole notched out. (fig. 2). A count of the latter quickly determines how many times cyclopropane was used. This group of cards can then be sorted for other variables, to compare with the same factors when other agents were used, and so on.

Fig. 2. The method used in Keysorting. Cards which are punch-cut will remain behind when the needle is lifted.

DESCRIPTION OF THE RECORD CARD

Except for the holes and some of the information printed adjacent to them, the Chicago Anesthesia Record has the same general appearance as the anesthesia charts now in common use. It measures 8½ × 11 inches and is printed on light Manila cardboard. Since the needs of potential users are quite varied, several different anesthesiologists were asked to help in deciding what to include. It was our hope to make the card nearly universally satisfactory, and we believe it will find widespread acceptance because of its completeness.
For those who require a copy of the graph for the patient's ward chart, the manufacturers will supply paper copies of the front side firmly glued along the top margin to keep the underlying copy on the card in perfect register. Carbons can be supplied with this combination or the user may insert his own. The card itself is filed numerically by the anesthetist for sorting at his convenience. The sturdy stock on which the card is printed will keep it in good condition for sorting, in spite of repeated handling by the anesthetists and secretary during anesthesia, postoperative rounds and filing.

**Standard Information**

Anesthesia number, hospital number, patient data, medication and spaces to indicate check of identity, character of breathing, and condition of the mouth, are near the top of the card. Induction complications are just below this, and on the right is space for "Remarks." None of these are coded directly, as any holes adjacent to them are for pre- and post-operative data, which are coded from the reverse side of the card. (fig. 3).

The graph itself has a half-hour period before the first hour line. (Note figure M at top of this line, for noting "A.M." or "P.M."). This helps to conserve space, considering how many operations booked "on the hour" must have their anesthesia begun a few minutes before the hour. Three and one-half hours of recording is allowed for. For longer cases, one must add a piece of graph cut from an old paper record, which can be glued along the left-hand side just inside the inner row of holes.

The three common inhalation agents are given a line apiece across the top of the graph, and two more agents may be written in. Oxygen consumption may be exactly recorded from 100 to 600 cc. per minute (or 10 to 60 per cent). In the space "Time of Remarks" are placed the symbols or numbers commonly used to identify the time of the notes made in the "Remarks" space on the right. A space for "Fluids" is at the very bottom of the graph. (Some use a wavy line to indicate the time during which saline and/or glucose is given, a thin straight line for plasma or albumen, and a heavy straight line for blood. This shows at a glance what has been used, and when.)

The remainder of the graph, and the spaces below it for recording agent, method, exact operation performed, and names of doctors and nurses, are not remarkably different from any other chart.

Where possible, the punch holes have been placed directly adjacent to the familiar locations for such data as physical status, condition during anesthesia, and position. To facilitate direct coding, it was necessary to print the list of body regions and pre-anesthetic drugs where space for holes would be available, namely, near the top edge of

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the card. For the same reason, the bottom edge of the card was used for anesthesia time, agents, method and anesthesia level.

**Coding—Front Side**

The various "fields" for coding will be described in clockwise order around the card, starting at the top left.
"Physical Status" needs no elaboration, other than to say that the categories follow those of the A.S.A. record system. The appropriate number is encircled.

"Site of Operation" is divided up generally along the lines of the A.S.A. code. Under each main heading, such as "Head and Neck," there are grouped those operations having the same general statistical significance. The A.S.A. code should be used in case of doubt as to the category for any specific operation. If an operation involving two regions is performed, only the more important operative site should be encircled.

"Major" or "Minor" Operation may be recorded or not, as the user wishes. The arbitrary definitions used in the operating room seldom give a true picture. Local "ground rules" may be made if desired for this space, if one does not desire such a classification.

"Year" is recorded by encircling the proper combination of numbers in the "Tens" space for the second last digit of the year, and the proper combination in the "Units" space for the last digit. Thus, 1958 would be coded by encircling 4 and 1 in the Tens space, and 7 and 1 in the Units space.

(If it is desired to code "Month," only the last digit of the year is coded, in the "Units" space. The "Tens" space may then be used for Month, which would be recorded by encircling combinations of numbers up to 10 for January through October. November may be coded 4, 2, and 1, and December as nothing, with no punch.

"Anesthetist."—Any number up to 19 may be separately coded. The figures to the left of the thin diagonal line are for numbers 1 to 9. Number 10 would be coded by encircling the 1 to the right of the diagonal. If only 9 anesthetists’ numbers are needed, this lone 1 could be used to indicate that the actual anesthetist was working under supervision, or to record any other desired fact.

"Premedication."—Since more than one drug is often used, they are printed in such a way that those used together are not opposite the same pair of holes. Thus, morphine and scopolamine are placed opposite different "fields," but since atropine and scopolamine are rarely used together it was feasible to have them on the same "field" of the card. The appropriate drug should be encircled as well as the corresponding hole for quick verification during the later punching. If none are used, the word "None" may be written across the space, for quick checking later when no notch is found during sorting.

* 1. Excellent; no systemic disease.
   2. Good; minor systemic disease only.
   3. Fair; moderately severe systemic disease.
   4. Poor; severe systemic disease.
   5. Good, emergency (those normally classed as 1 or 2).
   6. Poor, emergency (those normally classed as 3 or 4).
   7. Moribund.
"Condition During Anesthesia" and "Anesthesia Complications."
-S or U is encircled, depending on whether the case is generally satisfactory or unsatisfactory to all concerned. The most weight should be given to whether the administration was physiologically satisfactory, and to whether operative conditions were good or not. All complications during induction, maintenance and recovery are recorded next, opposite the appropriate designation. A few words in Remarks should identify the exact nature of the complication. "Minor" disturbances are encircled in the outer row of holes; "Major" ones in the inner row.

"Position."—The appropriate numbered hole and the name of the position are circled, for later verification. If the position is "supine", only that word is encircled. A card with no punch in the "Position" fields will indicate supine position.

"Anesthesia Level" follows the A.S.A. code closely. The outer row of holes is for general anesthesia only; the inner row for regional. "Anal." refers to analgesia with general anesthetic agents only. Regional methods should be recorded as "Satisfactory block", or according to the level that spinal, epidural or caudal anesthesia reaches. Both inner and outer rows may be coded.

"Anesthetic Methods" follows the A.S.A. code in most respects. Some consolidation has been necessary, generally by putting methods of similar significance together. Thus, "Open" and "Insufflation" are on the same field, as are "Peridural," "Caudal" and "Sacral." There are two spare fields for the less common regional and general anesthesia methods not listed. One principal method is recorded by encircling the proper words and the adjacent inner hole. Secondary methods are recorded by encircling the name of the method and the corresponding outer hole.

To simplify sorting it has been found useful to have a place to code whether more than one method has been used. This field is just to the left of "Anes. Level," and two or three (or three plus) methods may be indicated by encircling 2 or 3+. "Oral" or "Nasal" punched in the next field will indicate intubation. Under "Positive Pressure," "Cont." refers to continuous excess pressure in the breathing bag, and "Inter." to intermittent pressure such as is used in controlled, assisted or artificial respiration. As in the A.S.A. code, the elaboration of a method by adding positive pressure or intubation does not call for coding extra methods. "Numbers of Methods" refers only to the number of basic methods used.

"Anesthetic Agents" include only those which have been generally accepted in the past. Newer agents for general anesthesia may be coded under "Other." Newer agents for regional anesthesia may be coded under "Other Block Agents." (Individual users could also code newer drugs in spaces marked for agents they do not employ.) One principal agent is recorded by encircling the name of the drug and the
adjacent inner hole. Secondary agents are coded by encircling the name and the corresponding outer hole. Curare has been given one hole of its own, which is to be punched from the side of the card instead of the bottom.

“Number of Agents” should be recorded in the same way as for method.

“Anesthesia Time” is self explanatory. Only one hole is circled, of course.

“Reflexes Present in O.R.—“Reflexes not present” was deliberately omitted, as alternatives need not both be punched for effective sorting. “No” should be written in if the hole is not to be punched. Recovery complications should be noted under “Remarks” and coded with “Anesthetic Complications.”

Coding—Reverse Side

Ample space for information regarding the patient’s social and civil status appear at the top. Surgical diagnosis and pre-anesthetic summary come next.

“Age” is written in exactly, and coded in adjacent holes by encircling the appropriate age group.

“Sex.” Only “Male” need be coded for sorting, but “Female” should be circled when appropriate, for completeness of the chart.

“Preoperative” and “Postoperative” complications are arranged in parallel form. During preoperative rounds, the existing complications are circled, or written in the proper spaces, as is customary. In addition, the subgroups into which the complications fall should be encircled, along with the appropriate holes. Thus if “Emphysema” is circled, also encircle “Respiratory Major” and its hole. If severe “Diabetic Disturbance” is found, the adjacent hole “S” should be encircled also.

Time signals are provided for the more important postoperative complications. For either major or minor respiratory disease it was felt that two main time divisions were adequate. Most respiratory complications directly related to the anesthetic period should show up by the third day; those occurring later usually would have some other etiology. In case of nausea and emesis, the division into less than, and more than, twenty-four hours will help differentiate the moderate from the severe.

Time of death actually has 3 subdivisions—(1) in the operating room; (2) up to three days; and (3) later (which would be represented by no punch-cut.) These seemed to be logical divisions to help separate death due to immediate and early complications from those due to pre-existing disease and late complications.

In the obstetrical section parity may be coded peroperatively by circling the correct term and the corresponding hole. Likewise, con-
dition of the baby can be recorded after delivery. If nothing is coded it would indicate that the baby was still-born or died without breathing. Such a fact should also be written on the chart.

In the event that no actual disease complications exist pre-operatively, the hole marked "No Pre-Op. Compl." should be circled. (Notations of parity would not count as complications.) If there are no postoperative complications, "No Post-Op. Compl." should be circled. These two holes are very important for the purpose of eliminating large numbers of negative cases from consideration when sorting for complications.

**Punching the Card**

The card has been completely coded for preoperative status during preoperative rounds. During operation, odd moments can be used to encircle the proper data on the front of the card. By the time the last postoperative visit is made, the postoperative condition will be completely coded.

It will be seen, then, that the only extra time needed will be that required to notch, or punch out the holes already coded. This will amount to less than one minute per card. Wherever an outer hole is circled the punch cut is made to include only the outer hole. If the inner hole is circled the punch cut will open both rows to the edge of the card. (fig. 1).

It is essential that in punching the outside holes one should avoid cutting too close to an inside hole. The jaws of the punch must cut beyond the widest diameter of the hole concerned, or the card will not drop out easily during sorting. The punch-cut should be perpendicular to the edge of the card, as a slanting notch will also impede sorting. The cards should be filed numerically for ready reference from the alphabetic card file. Great care must be taken in filing and handling cards after they are punched. The notches near the corner tend to get caught on each other, and the corners get bent. This will interfere with easy sorting.

Any careful individual can punch the cards. If the anesthetist does not do this personally he should scrupulously scan each card front and back before turning it over to another for punching. In our experience to date, the most frequent omissions during coding are of physical status, condition during anesthesia, number of agents and methods, intubation, and no preoperative or no postoperative complications.

**Sorting**

Since no two persons will have the same plan, or want the same data, no complete sorting scheme will be discussed. General principles and a few examples should suffice.
The basic idea of Keysorting has been described by Pender (4) for a numerically coded card. His method will be used with this card only in the case of date and anesthetist. It should be noted, for example, that the cards of anesthetists number 10 to 19 should be separated first from those with single numbers, by using the sorting needle on the lone “1” just below the top right corner. The two main groups of cards resulting can then be sorted separately in reverse order, using one or two needles, as required. Two needles must be used for each number that requires two holes to form that number.

In any sort involving two holes on the same field (one inside the other), the cards should usually be sorted first for the data concerning the inner hole. Also, when sorting for agent or method, it is much simpler to divide the cards up first according to whether one, two or more agents or methods were used.

Suppose it were desired to know the incidence of major respiratory complications by body region. One hundred to two hundred cards at a time are carefully stacked with all the cut-off corners at the upper left, with the graph side facing the sorter. One needle at a time is then inserted in turn in each of the holes numbered 1, 3, 5, and 7 in “Head and Neck.” Four groups of cards will drop. This is repeated with another bundle of cards till the whole series is completed. (Cards punched 2, 4, 6, and 8 will have dropped out as 1, 3, 5, and 7 were sorted.) We now have a moderate sized pile of cards representing “Head and Neck.” A needle inserted in “Respiratory Major” (postoperative) will quickly find all the cards we are interested in. The whole process is repeated with the larger remaining stack of cards for other body regions. Counting is done by hand.

An interesting sort is one involving a search for a specific group of factors. This cannot be done with I.B.M. cards on ordinary sorters. With Keysort cards it is simplicity itself to pick out all the cases for a year that have, say, this combination of data: age in the fifth decade, sex male, with a minor preoperative respiratory disease, physical status 2, principal anesthetic agent ether, and a major respiratory complication postoperatively.

Since this latter complication would probably be the least frequent of all factors punched, all cards with major respiratory disease postoperatively would be sorted out first. The small number of cards dropping off the needle would be those with this positive finding. Then, 4 needles would be used simultaneously to find the cards among these with the 4 preoperative factors. Finally, those punched for ether would be sorted, using only the inner hole. The result would be available in about fifteen minutes if one were sorting 5000 cards, yet it is just the sort of information one may often need when faced with a question. A similar sort for comparison with other agents would require only a few minutes more.
The Keysort method is particularly useful in picking out all the records of cases in special categories. For example, one might desire to compile the data about all operating room deaths in one year. Not only would the sort be quick and simple, but the actual detailed records would be produced in only one step. This feature should be quite useful in preparing papers on specific subjects.

**Discussion**

The question has been asked, "Is the direct Keysort method satisfactory from every standpoint as the Hollerith or the Pender coded Keysort system?"

**Cost**

Except for the initially higher cost, as compared with paper chart plus I.B.M. card, the answer is that any Keysort method is far less costly because punching and sorting are so inexpensive.

**Simplicity**

There is no need for special trips to a sorting room or shipping of cards to a sorting center. This means greater availability than the I.B.M. card provides. The actual anesthetic administrator makes the only check needed on the data before turning the card over to a clerk for punching and filing. The Chicago Anesthesia Record has an advantage over the Pender card in that coding and punching is "direct." No code-book is needed, and sorting is simpler. Using the original record gives the Keysort card a special advantage over the Hollerith punch-card—when one gets past the large groups in a series of sorts, it is a great help to have such a simple method of picking out sub-classifications, and to be able to sort small groups of cards by sight. With the I.B.M. sorter, it is just as much trouble to sort 50 cards as 500, for the data cannot be read off the I.B.M. card except by experts, nor can they be sorted manually with a needle. The I.B.M. system admittedly is a little faster when dealing with very large groups of cards, especially in counting them.

**Time and Effort of Preparation**

This is where the Chicago Anesthesia Keysort out-shines all other except Nosworthy's. The Hollerith and Pender cards require a complete, separate process for coding and punching. Coding for Hollerith cards cannot be done simultaneously with case recording except with charts having special spaces for writing in code numbers. Even with that feature there is still the great expenditure of time looking up code numbers. This must be done by the physician concerned, or the results are worthless. The same is true of Pender's card. Some Hollerith
card users even insist that punching must not only be done by one familiar with the code but by an anesthetist, so that inadvertent errors can be corrected during punching. Actually, if errors are made in the original coding of an I.B.M. or Pender card it is not as easy to detect them as with the Chicago Card, where coding and punch-out are immediately adjacent, with the original data on the same record.

Specificity

It has been claimed that direct coding results in insufficient specificity of statistical data. Most of the data coded on the face of the card is almost as specific as on the Hollerith or Pender card, as far as essentials are concerned. This criticism has been levelled particularly at the coding of operation and of pre- and post-operative complications. The exact nature of the operation has no real significance in anesthesia statistics. Site of operation is important, as most of us have realized in studying respiratory complications.

Judging by past reports, few attach significance to the exact complications. Most statistics use such groupings as we have, into major and minor only. Study of individual case records helps more in determining etiology of specific disorders. Merely amassing large numbers of records of pneumonia to compare with a group showing atelectasis will not help materially in finding out etiological factors. So many factors are involved that even a system as complete and as mechanized as the I.B.M. would "bog down". What we wanted, and have provided, is a means for readily picking out the less common complicated cases from enormous numbers of cases without such complications. Once we have done this, a quick hand-sort of exact complications can be done visually, if we wish to study these cases individually.

It is possible to code many more complications with this card than with those using numerical codes. At best, they provide space for only 3 preoperative complications, 2 operative and 3 postoperative. By giving up unwanted specificity, we have not only eliminated the need for a code-book, but have provided for simultaneous coding and sorting of over 20 preoperative complications, 5 operative, and 15 postoperative.

Conclusion

The Chicago Anesthesia Record Card (Keysort) provides a method for direct coding of all important anesthetic data and the sorting of such data using only the original anesthesia record. No special knowledge is needed to use the card, except that already available to any anesthetist. No code-book is necessary, and the extra equipment required is both simple, inexpensive and continuously available. No initial expenditure of time or effort is required beyond that already used in making the usual anesthesia records. For these reasons it should
appeal to private practitioners of anesthesia, and to all departments
of anesthesiology that cannot find time or money for the more com-
plcated statistical sorting methods. It should help all those now
making good records to turn out equally good statistics as a means of
frequently assessing their clinical efforts.

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606–610 (Nov.) 1946.

MEETING OF THE CONNECTICUT STATE MEDICAL
SOCIETY

156 ANNUAL MEETING, April 28, 1948

ROGER LUDLOWE HIGH SCHOOL, FAIRFIELD, CONNECTICUT

PROGRAM

9:00 A.M. General Session.
1. "Integration of Anesthesiology in Medicine"—Edward B.
Tuohy, M.D., Professor of Anesthesiology, Georgetown
Medical Center, Washington, D. C.

2:00 P.M. Section on Anesthesia.

1. Business Meeting.
   (a) Old Business.
   (b) New Business.
       1. Election of Officers.
       2. Annual Program.

2. Scientific Session.
   (a) Address of President—Stevens J. Martin, M.D., St.
   Francis Hospital, Hartford, Conn.
   New Haven, Conn.
   (b) "A New Method of Parenteral Medication and An-
   esthesia with the Hypospray"—Edward B. Tuohy,
   M.D., Georgetown Medical Center, Washington,
   D. C.
   (c) "Peripheral versus Central Depression in Anes-
   thesia"—William T. Salter, M.D., Professor of
   Pharmacology, Yale University School of Medicine,
   New Haven, Conn.