TRENDS IN ANESTHESIA AS INDICATED BY A SAMPLING OF THE LITERATURE

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"Trends" is a popular word in the titles of articles pertaining to anesthesia. By what process trends are determined by the authors is rarely stated. Observations of actual practice, personal experience, or a study of the literature may have been, either alone or in combination, the methods used to indicate the course which is being taken in the practice of anesthesia. At times during the preparation of material for publication in Anesthesia Abstracts and the reading of books on anesthesia, it seemed that there were patterns; use of some anesthetic agents or methods was declining while interest in others was increasing. To determine, if possible, these or any other patterns was the object of this study.

MATERIAL

Books constitute an important part of the literature on anesthesia. It was decided to make them the subject of a separate study which it is hoped will be reported later. The "papers" or articles which appear in periodicals are another large part of the literature. It is with this group that this study is concerned. To follow the pattern for more than the century since the introduction of anesthesia for clinical use might be interesting, but a task of such magnitude was not feasible at this time. The material chosen for this study was the abstracts of the 5,900 articles from medical journals prepared for publication in the first 24 volumes of Anesthesia Abstracts.¹ Most articles abstracted in those volumes were published in a period of 12 years, 1935 through 1946.

Our familiarity with the content of those articles made these abstracts particularly suitable for study. Some articles included in Anesthesia Abstracts were published before 1935; some as early as 1842. Because a great degree of selectivity had been used in choosing those earlier articles, and because they represent such a small part of the total literature for that period, they were omitted from this study. Because the articles published in 1947, abstracts of which will appear in volume 24, represent an incomplete picture for that year, they, too, were omitted. Abstracts of articles on blood transfusion which have appeared in Anesthesia Abstracts also were deleted because much selectivity had been used in this category and it was believed that a fair pattern would not result. After these deletions the

Approximate Number of References in Quarterly Cumulative Index Medicus under Heading of Anesthesia

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*1946 figures estimated from first half of year.

remaining number of abstracts totaled 5,107. These actually constitute the material for this study.

How much of the total literature do these articles represent? There are about 5,000 medical journals; of these only 1,200 were available as sources for material for Anesthesia Abstracts. It would seem then that less than 25 per cent of the material was reviewed. Actually of the 1,200 journals only 283 contained articles on anesthesia. These 283 journals represent only 5.6 per cent of the 5,000 journals. That would seem to be a very small part of the total literature. These percentages give a misleading picture of the percentage of articles used as compared with the total published. A more accurate idea will be obtained from a survey of the references in Quarterly Cumulative Index Medicus for the years covered by this study (see table).

The 5,107 abstracts of articles with which this study is concerned actually represent more than 56 per cent of the total and 109 per cent of the articles on anesthesia printed in the English language as indicated by the Quarterly Cumulative Index Medicus. A few translations, some excerpts from articles on surgical and other systems, and from listings other than “anesthesia” in the Quarterly Cumulative Index Medicus account for this high percentage.

No attempt was made to include chapters in books, all systems of medicine and surgery, or material from ad-

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vertising journals. From the available periodicals in English all articles on anesthesia were abstracted, and, as said before, a few but not many translations from foreign languages were made.

**Method of Classification**

The abstracts were reviewed, and each was placed into a category which indicated the main subject, or subjects. The titles were not always a true indication of the content of the article. If there were three or less main subjects in an article, each subject was classified separately. Thus, in the details on most subjects which follow, the word "reference" is used. When an author discussed more than four subjects in one article, that article was placed in a subcategory called "general discussion." Four main categories were used as follows: (1) agents, (2) methods, (3) applications, and (4) miscellaneous subjects. Articles which did not logically fall into the first three categories were placed, for purposes of this study, in the fourth group, although there was no relationship between some of the subjects. The data on agents were arranged in two groups: agents used for general anesthesia, and those used for other types. Graphs were then constructed for each of the subjects in each category. From these graphs it was hoped that patterns or trends could be deduced.

**Agents (figs. 1 and 2) Used for General Anesthesia**

**Barbiturates.**—Of all agents used for producing general anesthesia, the barbiturates were the subject of the largest number of references during the 12 year period. All articles on barbiturates in which the drugs themselves were the subject of the discussion were included in this category. Conversely, in the plan used, when the method was the main subject of an article, the incidental mention of a drug or drugs did not constitute enough interest to warrant its inclusion in this group.

In 1935, there were 44 major references to the barbiturates. A sharp increase occurred in 1936, followed by a consistent decline in interest until 1940, when only 25 references appeared. Gradual increase of interest resulted until 1944 when another, less acute decline occurred, and in 1946 the interest as indicated by the number of references again increased. During the 12 year period 574 references on the barbiturate group of drugs appeared.

**Cyclopropane (fig. 1).**—Of the agents which are used for general anesthesia, cyclopropane was the subject of the second largest group of articles. Here the greatest number appeared in 1937 when there were 26 references. The total number of references during the 12 years was 153.

**Ether (fig. 1).**—Diethyl ether was considered as a single unit; some of the newer ethers were placed together in another group. Diethyl ether was the main subject of 129 references with no spectacular increase or decrease of interest throughout the period under consideration.

**Nitrous oxide (fig. 1).**—This was the fourth agent of interest as indicated by 122 references. There was a marked peak in 1937.

**Divinyl ether (fig. 2).**—The fifth in this series of general anesthetic agents has been the subject of 45 major references with slight peaks of interest in 1937 and 1938.

**Trichlorethylene (fig. 1).**—There were 37 references on trichlorethylene, and the peak of interest was in 1943.
Chloroform (fig. 1).—The 26 references on chloroform make it seventh in line of interest which increased slightly in 1941.

Ethyl chloride (fig. 1).—This was eighth in the group with 19 references.

Newer ethers (fig. 2).—This subgroup includes cypreth, cyprohe, cyprethylene, and others of the recently introduced ethers. Sixteen references appeared on these newer ethers, the first of which was in 1938. The number of references on these agents was ninth in the group.

Ethylene (fig. 1).—The tenth and last agent in this group was the subject of a declining interest. Of the 12 articles primarily concerned with this agent only one has appeared in the past six years.

Agents Other Than Those Used for General Anesthesia (fig. 2)

Local anesthetic drugs.—In this group, as in the barbiturate group, distinction was made between the agent and the method. Of all of the agents, local anesthetic agents were the subject of the second largest number of refer-
ences, a total of 241 having appeared. The point of least interest as indicated by the number of references occurred in 1938 and of greatest interest in 1944.

Analeptics.—These drugs were the subject of 183 articles. There were marked peaks of interest in 1939 and 1942, with the lowest points in 1943 and in 1945.

Agents for premedication.—This has been the main subject of 210 articles with a gradual increase from 1940 to 1946.

Oxygen, carbon dioxide, and helium.—These gases have been the subjects of 76, 29, and 15 articles, respectively. Interest in each has declined.

Avertin.—A peak of interest in this drug was reached in 1936 when 18 of the 59 references on the subject appeared.

Paraldehyde.—Interest in paraldehyde as in avertin has declined during the period under consideration. Thirty-nine references are listed during that period with a peak in 1937.

Fig. 2.—Variation in the number of articles on divinyl ether, newer ethers, and certain other agents from 1935 through 1946.
Curare.—This agent, which appeared in the literature on anesthesia for the first time in 1942, has been the main topic of 72 articles, 42 of which appeared in 1946.

**General Discussion (Fig. 2) of Certain Agents and Methods**

In this group are included all those articles in which so many agents or methods were mentioned that no attempt was made to break them down into the other categories. Such articles were often reviews or general surveys and often contained in their titles the words, “trends,” “progress,” “reports,” or “observations.” An attempt was made to eliminate from this group all except those articles which were actually general discussions of anesthesia. Those persons who may feel that any one group thus far described does not give a fair picture of any particular agent may add a share of the articles from this group to his favorite agent and thus bolster its standing. A breakdown within this group to the various agents would probably add only to the size of the figure for any one agent without greatly altering its relative position in this survey. There were 532 references in this group with a marked peak in 1942 when 59 of these articles appeared.

**Methods (Fig. 3)**

Nine methods of administering anesthetics appeared with sufficient regularity in the literature to warrant inclusion in this section.

**Regional (including spinal) anesthesia.—**The 673 references in this

![Graph](image-url)

Fig. 3.—Variation in number of articles on nine methods of use to anesthetists.
group make this subject the one of greatest interest in the whole series. Since the lowest point in 1937 and in 1938 when 36 references appeared each year, there has been an erratic rise in number up to 1946 when 83 references appeared. This number was the greatest single figure for any subject for any one year.

**Intravenous anesthesia.**—The 287 references on this subject during the 12 year period make this method second in importance as indicated by this study. The greatest peak in number of articles occurred in 1945, when 38 references were listed.

**Continuous caudal anesthesia.**—This subject could have been included under regional anesthesia. Its newness was the criterion on which a separate listing was based. There were 106 references to this type of anesthesia which first appeared in the literature with 2 articles in 1942. In 1944 a sharp increase brought the total for that year to 42 references, and an almost equally sharp drop resulted in only 10 references in 1946.

**Rectal anesthesia.**—The 72 references on this subject place it fourth in this section. The peak of interest occurred in 1936 when 15 references were listed. During recent years a rapid decline has taken place; in 1945 and 1946 no references on this subject appeared.

**Intratracheal anesthesia.**—This method of administering anesthetics with 62 references shares fifth place in this section with refrigeration anesthesia. No spectacular variations occurred in the graph in the period, although interest in recent years has increased gradually.

**Refrigeration anesthesia.**—In our samples of the literature, refrigeration anesthesia was not mentioned until 1941. Since then 62 references have appeared with a peak in 1944 when there were 25.

**Continuous spinal anesthesia.**—This is seventh in this group with 47 references to it since its introduction in 1940. Although there was no spectacular rise in interest, as there was in continuous caudal anesthesia, neither was there a precipitous fall.

**Carbon dioxide absorption.**—This has been the main subject of 44 references, and a slight increase of interest was noted in 1941.

**Electric anesthesia (not shown in fig. 3).**—This method was included because it seems to persist. Only nine references have appeared during the 12 years, but the subject seems to cling to its small hold on the interest of the writers of anesthesia literature.

**Applications (fig. 4)**

The frequency with which certain uses of anesthesia were the principal subjects of articles determined their inclusion in this section. Eight major classifications were used.

**Obstetrics.**—Anesthesia for obstetrics was a major subject of 318 articles. A great interest was indicated in 1937, the least in 1939, when only 14 references appeared. Since then a rapid increase may be noted with the highest peak in 1946 with 42 references.

**Diagnosis and treatment.**—Writers of articles on anesthesia have been consistently interested in its diagnostic and therapeutic uses. In the 12 year period 181 references appeared without any spectacular variation in the number from year to year but a gradual increase to 1946 when 33 references appeared.

**Wartime uses.**—Wartime uses of anesthesia have been the subject of 153
Fig. 4.—Comparison of number of articles on eight uses of anesthesia from 1935 through 1946.

Articles with a peak in 1944. As early as 1935 one reference appeared, but 1941 showed the first great increase. A rapid decrease occurred in 1946.

Dental anesthesia.—Interest in anesthesia for dental and oral surgery has been sustained. No spectacular peak has occurred, although in 1936 22 of the 152 references on the subject appeared.

Thoracic surgery.—Anesthesia for thoracic surgery has been the subject of 97 references with a gradually increasing interest from 1940, when one reference appeared, to 1946, when there were 20.

Children.—Anesthesia for children has maintained a fairly constant interest with peaks in 1936 and again in 1946. A total of 62 references appeared in this group.

Bronchoscopy.—Casual but persistent interest in this subject is indicated by 24 references which have appeared with no marked variations in number over the years.

Geriatrics.—Anesthesia for the aged has been the subject of only 14 articles, 11 of which have been published since 1943 when the word “geriatrics” first appeared in these articles.

Miscellaneous Subjects (Fig. 5)

Complications.—Articles in which complications during and following an-
esthesia were the main subject rank high in the total count. There were 442 in the period under consideration; two peaks of interest occurred, one in 1936, when 45 references appeared, and the other in 1944, when there were 56.

Asphyxia.—In this category were 72 references. Anoxia, anoxemia, and asphyxia were all classified in this one group. Interest has been consistent with the highest peak in 1937.

Shock.—References on this subject increased spectacularly from 2 in 1935 to 42 in 1943. The decline was equally

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![Graph showing the number of articles on nine miscellaneous subjects from 1935 through 1946.](image_url)
sizable; only four references appeared in 1946. The total number for the 12 years was 154.

_Resuscitation._—We had some difficulty in properly classifying some of the articles on resuscitation because, in the older implications of the word, there was some overlapping with the material on asphyxia and complications. In the more recent interpretation of the term there was some overlapping with shock. Generally, the references in this group are representative of the older interpretation, that is, artificial respiration, cardiac massage, and such measures. There were 71 references in this group with a peak in 1936.

_Explosions._—Forty-eight references appeared on this subject with a gradual rise to a peak number in 1941 and a gradual decline since that time.

_Apparatus._—A fluctuating but consistently upward trend in the number of references each year occurred in this group. There were 113 articles during the 12 years, in which devices of all kinds used in the practice of anesthesia were the chief objects of discussion.

_Medico-legal aspects._—References on this aspect of anesthesia appeared only 29 times in the entire series. Fourteen of the articles were published in 1936.

_Organizations._—In this category are included those articles in which anesthetists, their organizations, and professional problems were discussed. There were 114 references to this type with a peak in 1936 and a variable degree of author interest for the other years.

_History._—Ninety-four articles were concerned with the historical aspects of anesthesia. A slight peak occurred in 1944 and an abrupt peak in 1946.

_Comment._—Other subjects could well have been included in this category of miscellaneous subjects. For instance, anaphylaxis in relation to anesthesia was the subject of six articles. In view of recent experiences with the use of mace during anesthesia and for unanesthetized persons, interest in the subject of anaphylaxis may be revived.

**Trends in Actual Use of Agents and Methods**

While we were studying figures 1 to 5 the question arose as to whether the trends as indicated in the literature were also trends in actual use. Another set of graphs was constructed in an attempt to answer this question.

The 270 articles written by the anesthetists at the Mayo Clinic in the same 12 year period were classified in the same manner in which the larger series was classified. Graphs were constructed. Then the annual reports of the Section on Anesthesiology of the Mayo Clinic for the same years were studied and the trends were compared with those from the reports. The percentage of the total instances of anesthesia in which each of 10 drugs or methods was used in each of the 12 years was determined, and graphs were made. During these years anesthesia was induced a total of 280,860 times at the clinic.

The lines of the graphs for the articles were then superimposed on graphs for the actual use of the agents. There was such a great discrepancy that in no instance could any detectable relationship between the two lines be demonstrated. To determine whether this tendency was general throughout the literature would require a similar comparison of the work of many anesthetists with the writings of those same anesthetists.

An attempt then was made to com-
pare the use of anesthetic agents or methods with the trends as indicated by the larger sample of the literature. The same lines of the graphs of the 10 subjects from the clinical use of the drugs and methods at the Mayo Clinic were superimposed on the line of the related subjects in the original graphs. Here there was at least some relationship but still no exact or even close approximation. Shifting of the graphs to adjust to the common delays of two or three years did not improve the comparison. Some of these comparisons are illustrated in figure 6.

The solid line represents the percentage clinical use of regional and spinal anesthetic agents. The broken line is the course of the same subject in the literature. No close relationship exists here. Another solid line represents the use of intravenous anesthesia in clinical practice, and the dotted line is that of the graph of the same method as indicated in the literature. Here again no true relationship exists. Other subjects showed even greater diversions and were not included in the graph. In only one instance was there a noticeable similarity; that was in the use of curare (fig. 6). Here the trend, although not so great in clinical practice as in the literature, was in the same direction for both graphs.

What do these graphs show? Some of the trends as indicated by the graphs lead to further questions. Some interesting observations can be made.

Fig. 6—Comparison of trends indicated by number of articles with actual use of agents or methods as determined by the percentage of the total instances of anesthesia in which they were used. Data came from the annual reports of the Section on Anesthesiology of the Mayo Clinic.
INTERPRETATION OF GRAPHS

The older agents and methods seem to have established a pattern from which they digress only after the introduction of a stimulating factor. That factor may be a competing agent or method, new evidence in favor of or opposed to the older agent or method, or new methods for applying old agents and vice versa.

Newer agents and methods seem to have a peak of interest in the literature two or three years after their introduction. It seems that when new methods or agents which are introduced require elaborate or new apparatus for their administration the lag is three years. Cyclopropane and continuous spinal anesthesia may be in this class. Two years seems to be a common interval after the introduction of a new factor, if no special equipment is required, before the peak of interest appears in the literature. Continuous caudal anesthesia and the barbiturates seem to illustrate this point (figs. 1 and 3). When an occasion can be anticipated, and when no series of experiences or experiments or no special equipment is necessary, the peak occurs almost coincidentally with the stimulating factor. The rapid increase in references to wartime use of anesthetic agents and methods and the historical references seem to illustrate this pattern.

Sudden peaks are often followed by equally sudden declines in interest. The graphs for continuous caudal anesthesia, for shock, and others show this trend (figs. 3 and 5). Some lines rise slowly to a level from which they do not vary greatly thereafter. Continuous spinal anesthesia is an example of this trend.

Some lines seem to follow a pattern almost parallel to that of another agent or method. Avertin and paraldehyde have such a course. Being somewhat similar in method of administration and application, this relationship seems understandable. Nitrous oxide and cyclopropane also have similar patterns. The relationship is less apparent than with avertin and paraldehyde, and the significance of the parallelism is conjectural.

There seems to be no definite correlation of interest in certain drugs per se and the methods by which they are given. For instance, local anesthetic agents do not follow the same line as that for regional anesthesia, nor does the line for barbiturates appear to be correlated with the line for the intravenous method although it would seem that there should be some correlation.

Each line on each graph could be followed with explanations and conjectures for each rise and fall. In so doing many variables must be considered. Some of these variables are as follows:

The war.—That the years covered by this survey (1935 through 1946) encompassed the war years is undoubtedly of much significance. Interest in anesthesia for wartime use and in shock increased greatly during the actual war years. The decline of interest after the war has been rapid. Anesthesia for thoracic surgery and diagnostic and therapeutic uses of anesthesia were of rapidly increasing interest during those years, but, unlike the two categories previously mentioned, the interest is continuing. The effect of the war on the total output of literature is interesting. The rapid decline in references under the category of anesthesia in the Quarterly Cumulative Index Medicus and the beginning recovery are apparent in the table. The geographic sources of
articles also underwent an understandable change. This trend can also be followed in the figures in the table. The material from journals printed in foreign languages varied from 64 per cent in 1935 to 22 per cent in 1942.

Authors.—Some authors are prolific in their output of articles on anesthesia. When such an author becomes the protagonist for a certain agent or method he may influence the trend in anesthesia as it is indicated in the literature. His enthusiasm for his own or another person’s contribution to the field of anesthesia may distort the pattern as it represents the actual clinical trend. Sometimes an author may contribute almost identical papers to several periodicals, again distorting the pattern. Failure of some workers to contribute anything concerning their work to the literature may again result in distortion of the pattern as far as it reflects clinical practice.

Stimulating factors.—New agents, when they are introduced, are followed by fairly discernible effects on the trends of those agents. The introduction of pentothal sodium in 1934 and the clinical use of cyclopropane, which was first reported in 1934, can be readily followed on the graphs. When newer agents or methods appear, interest in the agent or method which the newcomer threatens to displace seems to be stimulated. The interest may be to defend the older agent or to compare it with the newer agent.

When a contribution of value is made to the literature, it is interesting to speculate on the effect of that contribution on the trends. How, for instance, did Courville’s monograph on asphyxia as a consequence of nitrous oxide anesthesia affect the trend of the graphs for asphyxia and for nitrous oxide? Did Moon’s book on shock affect the trend of interest in what subject? Could the sudden peak of interest in continuous caudal anesthesia be partially attributed to the fact that its originator was the author or co-author of more than 10 per cent of the references? Did the death of J. T. Gwathmey in any way contribute to the decline of interest in rectal anesthesia?

Physician anesthetists.—Did the increasing interest of physicians in the specialty of anesthesia greatly affect the trends? It is probably too early to evaluate this factor. It seems significant that although it has been estimated that in five out of six instances anesthetic agents are not administered by physicians, the preponderance of authors of articles in this study are physicians.

Comment

Endless speculations could be made along these and other lines. No attempt has been made to explain many of the trends. A greater study of causes and effects than has been made might reveal interesting facts. Why, for instance, was there greater interest in anesthesia for children in 1936 and again in 1946 than in other years? The rise in interest in anesthesia for obstetrics in 1944 could have been the result of the introduction of continuous caudal anesthesia. Was there a stimulating factor to explain the peak of interest in 1937? Study of the graphs does not result in a satisfactory explanation on that basis.

(Continued on page 224)

a gain in weight, a lowering of the pulse rate, and a progressive decline in the basal metabolic rate. Cyclopropane is a dangerous anesthetic for these patients because the heart muscle is already hyperirritable. A free airway is important, and for this reason intratracheal anesthesia is to be preferred.

**Summary**

Anesthetic risk and surgical risk are inseparable factors, since the anesthesia must be conducted and the operation performed simultaneously. Both anesthesia and surgery are actually, as well as potentially, harmful, and both must be employed so as to minimize the harmful effects of each while an attempt is made to attain the hoped-for benefits of the surgical procedure. In most cases the risk of surgery is greater than the risk of anesthesia. Anesthetic risk relates principally to those cases in which the harmful pharmacologic effects of the anesthetic agent combine with physiologic disturbances that actually or potentially exist in the patient to produce serious or fatal consequences. The principal harmful pharmacologic effects of anesthetics are depression of respiration, lowering of blood pressure, and increase in irritability of the heart muscle. The roles which may be played by these effects in persons with hypertension, hypotension, anemia, and disease of the heart, lungs, kidneys, liver, and thyroid gland have been discussed. The greater the number of vital organs involved by disease and the more extensive the involvement, the greater the risk of anesthesia and of surgery. However, an appraisal of the general condition of the patient—how he looks, how he feels, how alert he is, how good his muscle tone is — furnishes the best evaluation of anesthetic risk.

**TRENDS**

*(Continued from page 199)*

The figures in the table, in addition to showing trends as to percentage of articles in foreign languages and yearly totals, show that, while the total output of literature on anesthesia during the war years was reduced, the percentage of the total articles that were in English increased from 1935 to 1944 and decreased during 1945 and 1946. Articles in foreign languages declined from 1939 to 1942 and have increased each year since then.

From an admittedly limited comparison of the clinical use of anesthetics with the literature it appears that there is no true relationship. The literature which is now being printed may be the only record which will remain. Will the picture which that record conveys be an accurate portrayal of the practice of anesthesia as it is today?

No positive conclusions have been drawn from this study. It may be that the patterns and the questions raised will be of interest to others who, like the authors, have wondered “What are the trends in anesthesia?”

**PENTOTHAL SODIUM**

*(Continued from page 220)*

been reviewed. It has been emphasized that the intravenous administration of drugs is merely another way of obtaining “general anesthesia.” Attention has been directed to significant reports dealing with administration and technics; concentrations of pentothal sodium in current use; rectal administration of pentothal sodium; detoxication; effect on the liver; contraindications; complications and overdosage.