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## TACHYCARDIA IN CHILDREN DURING ANESTHESIA \*

KATHERINE JACKSON, M.D.

*New York, New York*

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IN accordance with the principle of maintaining the physiologic processes of the patient as nearly normal as possible during anesthesia, it seems advisable to study and to try to prevent the extremely rapid pulse rates which often develop in the anesthetized child. This is increasingly important in view of the rising incidence of the cardiac diseases. There is no evidence to prove that these excessively rapid rates are as harmless as anesthetists have often considered them to be. Moreover, greater numbers of children with known cardiac abnormalities and diseases are now being given the benefit of surgery. These children should surely be given every possible protection against unphysiologic reactions.

The purpose of this study is to determine the effect of four factors upon the average maintenance pulse rate during anesthesia, namely: preanesthetic apprehension, premedication with nembutal, the agent used, and the technic of administration.

### METHOD

In 108 children, ranging in age from 9 weeks to 12 years, the pulse rate was recorded at frequent intervals during the anesthetic period. These readings were then averaged and a figure obtained which represents the average maintenance pulse rate of each child during one anesthetic period. These individual averages were used to compute a general average maintenance pulse rate for the entire group.

As a "physiologic goal," an average pulse rate was computed on the basis of repeated pulse readings, on the wards, of the same group of children as that used in the study, when they were not in the operative period.

\* From the Hospital for Special Surgery, New York, New York.

In 64 of the patients, accurate information was recorded concerning the preanesthetic psychic state of the child. The general average maintenance pulse rate of this group was determined, and found to coincide with that of the entire group studied (fig. 1).

About half of the children received nembutal premedication, usually in the form of a suppository containing 66.6 mg. of the drug. A few of the older ones were given by mouth a capsule containing nembutal, 49 mg. These patients were also given codeine sulfate subcutaneously, 33.3 mg. to 66.6 mg. depending upon age. Those who received no nembutal included children under 2 years of age and 10 children over

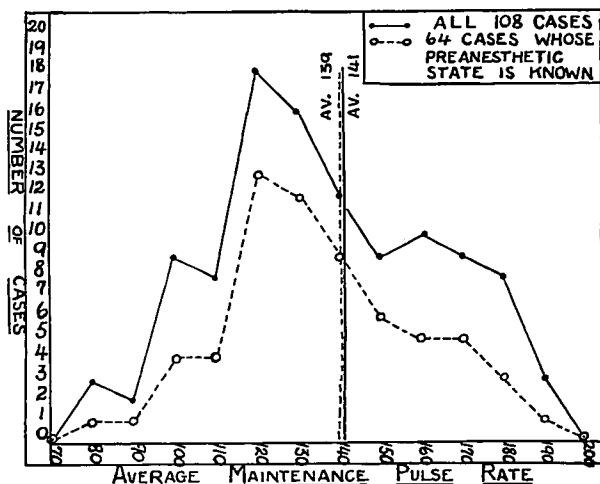


FIG. 1. Comparison of average maintenance pulse rates of cases in which the preanesthetic psychic state is known with those of the entire series.

10 years of age who were given morphine or demerol, as well as several children in the intermediate age group for whom the nembutal was inadvertently omitted. The time of administration was about one hour prior to the induction of anesthesia.

About half of the group was anesthetized with cyclopropane as the sole anesthetic agent except for small amounts of nitrous oxide used during induction. The machine used was the circle filter type with carbon dioxide absorber. The other half of the group was given ether as the sole agent, except for minimal amounts of ethyl chloride sometimes used during induction. Except for 12 patients who received

ether-oxygen in a closed system, ether was administered on an open mask or by pharyngeal insufflation. No case in which combinations of agents or technics were used was included in the averages.

The numerous other factors which admittedly affect pulse rate, such as depth of anesthesia, surgical shock, oxygenation, carbon dioxide retention, and fluid therapy, were considered to be fairly well averaged in the entire series. In the smaller sub-groups, however, it is recognized that such factors must be considered as influencing the average pulse rate.

A little more than half of the operative procedures were orthopedic, of which about half lasted more than forty-five minutes, and the remainder forty-five minutes or less. Forty-four per cent of the total were general surgical operations, principally hernioplasties and other plastic procedures. In the latter group, 20 per cent were of more than forty-five minutes' duration. No appreciable difference was found in the average pulse rates in the different surgical groups.

The average maintenance pulse rate of the entire 108 cases was found to be 141 per minute. Among the 46 children 6 years old and under, this rate was 157 per minute. For those from 7 to 12 years (62), the rate was 129 per minute.

The "control" or ward pulse rates were: for the entire group, 110 per minute; for the younger group, 116 per minute, and for the older group, 101 per minute.

#### EFFECT OF PREANESTHETIC PSYCHIC STATE

Of the 64 children whose preanesthetic psychic state was known, 25 showed no evidence of fear at the time of induction of anesthesia. Of these, 7 were in the younger age group, and 18 in the older group. Using the aforementioned averages for the two age groups, the expected average pulse rate should be 137 per minute. Actually, the average was 128 per minute (fig. 2).

The group in which the children were apprehensive was more evenly divided as to age (21 younger and 18 older) and showed an average rate of 147 per minute, or 14.8 per cent higher than the group which showed no fear.

The older age group was exactly divided, that is, 18 were and 18 were not apprehensive at induction. The average pulse rate for those who were without apparent fear was 121 per minute. Among the apprehensive older children, the average was 138 per minute, or 14 per cent higher than that of the group which showed no fear (fig. 3).

Almost all anesthetists probably prefer to have their patients in a quiet and cooperative state of mind, and no doubt a majority exert some effort to make the induction as free as possible from unpleasantness. Many even make attempts to allay the patient's very normal fear of the unknown, and to minimize the psychic trauma of an experi-

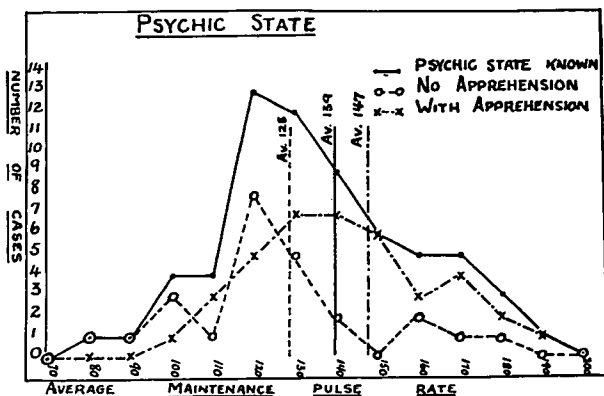


FIG. 2. Effect of preanesthetic state on average maintenance pulse rate: 25 patients who showed no fear and 39 patients who were apprehensive.

ence that is at best a terrorizing one, especially for a child. On the other hand, one still hears occasionally the statement that it is better for a child to cry and fight, for he breathes more deeply and goes to sleep more rapidly.

There is no doubt that preanesthetic apprehension can do a child physiologic harm, nor that it can make the anesthetist's task of administering safe and relatively harmless anesthesia much more difficult.

In a paper on Anesthesia in Infant Surgery, Mary Botsford (1) advised that crying before and during induction should be avoided because it increases secretions and causes a sobbing type of respiration, necessitating deeper anesthesia to obtain relaxation and a quiet diaphragm. Macon (2) speaks of the panic-stricken child as "a poorer operative risk" and calls attention to the postoperative neuroses and

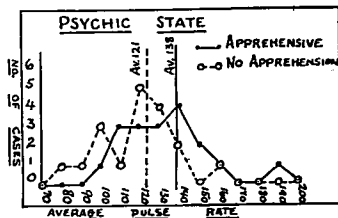


FIG. 3. Effect of preanesthetic psychic state in the same age group: 18 patients who showed no fear and 18 who were apprehensive.

psychoses which may follow unguarded remarks in the induction room or hurried and careless attitudes on the part of personnel. When dealing with children with organic heart disease, it is imperative to avoid preoperative excitement. On the basis of experience in anesthetizing children for cardiac surgery, Harmel (3) stated that excitement causes dyspnea, cyanosis, convulsions, loss of consciousness and even death. (He advised, however, that pulse rates in this type of case should not be allowed to fall below 120 per minute.) One writer goes so far as to state that preoperative control of apprehension should be psychologic rather than pharmacologic. Murphy (4) believed that doses of preanesthetic medication large enough to control the child's fear and to reduce the amount of the anesthetic agent also reduce the controllability of the inhalation anesthesia.

A discussion of the methods of preventing or reducing preoperative apprehension is outside the scope of this discussion. Suffice it to say that more and more factors are known to be important as we learn more about the mechanisms that govern the child's mental and emotional development.

#### EFFECT OF PREMEDICATION WITH NEMBUTAL

Of the 53 children who received nembutal premedication, 19 were in the younger, and 34 were in the older group. Fifty-five patients received no nembutal, of whom 27 were in the younger and 28 in the older group.

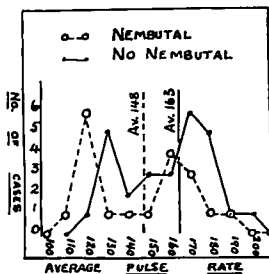


FIG. 4. Effect of nembutal premedication in the younger age group: 27 cases with nembutal and 19 cases without.

With the older children, a slower average pulse rate was noted when nembutal was not used. It will be remembered, however, that 10 of these children received morphine or demerol. When these cases are excluded from the average, the remainder showed an average rate of 131 per minute. The older children who had received nembutal had an average pulse rate of 133 per minute.

In the younger group, however, the average rate of those receiving nembutal was 148 per minute, whereas those who had none had an average rate of 163 per minute, which is well above the average for the age group, and 10 per cent above the rate of those who received nembutal (fig. 4).

This apparent difference in effect in the two age groups may well be a matter of adequacy of dosage, in which case we may say that an adequate dose of nembutal preoperatively is associated with a somewhat lower maintenance pulse rate than the average rate, and definitely lower than without such medication.

Concerning the premedication of children, Leigh and Belton (5) recommended the use of both opiates and barbiturates for the purpose of curbing the exhausting rapid respiratory rates and of reducing the amount of the anesthetic agent required. The barbiturates, they believe, reduce or prevent the postoperative emesis which occurs following the preoperative use of morphine. Murphy (4) advised the use of barbiturates in those cases only in which they are specifically indicated for their action in preventing the harmful side-effects of the local anesthetic drugs. Leech (6) has abandoned the use of the barbiturates because he has found the degree and the time of their effect unpredictable.

The pharmacologic basis for preoperative medication is discussed by Dripps (7). He stated that in addition to the psychic sedative effect, there is an additional reduction in the reactivity and irritability of all body tissues, and that because of this effect on muscular and nervous tissue, less anesthetic agent is required. Barbiturates, he said, do not produce the smooth muscle stimulation which is shown by the opiates, and can be used without fear of increasing postoperative nausea and emesis. Evidence to corroborate Dripp's statement concerning the existence of a physiologic as well as a psychic sedative effect of the barbiturates appears in one of the later parts of this study.

#### EFFECT OF ANESTHETIC AGENT

The experimental work of Adriani and Rovenstine (8), in 1940, on turtle and frog hearts indicates a parasympathetic action of cyclopropane, which is a common impression at the operating table.

In the 48 cases in this study in which cyclopropane was used, the average pulse rate was 128 per minute. Although only 7 of the children were in the younger age group, when the expected average is computed on the basis of age distribution it is found to be 133 per minute. Interestingly, the rates in the two age groups are identical which, considering the basically higher rate in younger children, indicates a much greater effect in this group.

In the entire group receiving ether (52 cases), the average rate was 155 per minute (fig. 5). Although the majority of these children were

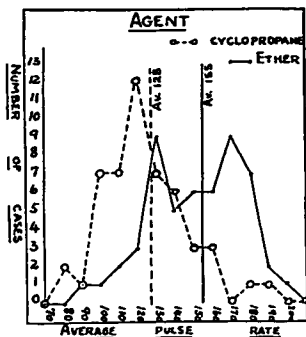


FIG. 5. Effect of agent on average maintenance pulse rate: 52 cases with ether and 48 cases with cyclopropane.

in the younger age group, the expected average according to age distribution is 149 per minute.

In the older group 14 children received ether and 41 received cyclopropane. The pulse rates in the ether group were found to average 137 per minute, or 6.2 per cent above those of the patients who were anesthetized with cyclopropane, which averaged 128 per minute (fig. 6).

#### EFFECT OF METHOD OF ADMINISTRATION

In considering the effect of the technic of administration, it must be borne in mind that cyclopropane is always given in a closed system, whereas ether may be used in a closed, a semiclosed, or an open system. In order to eliminate the difference in drug effect, only those cases in which ether alone was used were included in this part of the study.

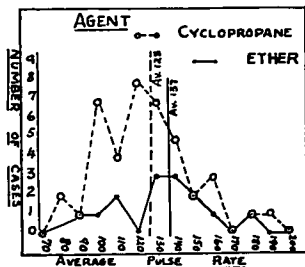


FIG. 6. Effect of agent in the same age group: 41 cases with cyclopropane and 14 cases with ether.

Thirty-seven children, with an average age of 3.2 years, were anesthetized by the open drop or insufflation technic. In 12 cases with an average age of 8.2 years, anesthesia was induced and maintained on a closed system. The average maintenance pulse rate of the patients with whom the open technic was employed was 162 per minute which, when compared to 157 per minute, the general average rate of the entire younger age group, is found to be an increase of 3 per cent. The average maintenance pulse rate of those with whom the closed system was used (average age 8.2 years) was 138 per minute. When this rate is compared to the general average for the older age group, an increase of 7 per cent is found. It will be noted that while each rate is higher than the average for its age group, the amount of increase is greater in the group in which the closed system was used.

Little is found in the literature on this subject. Macon (2) considered the open system to be better for children under 3, and certainly that is the commoner practice. The choice, however, is usually made on the basis of convenience or is determined by the type of equipment at hand. Botsford (1) recommended a semiclosed system in infants to conserve the patient's body heat by avoiding the chilling effect of the vaporizing ether.

#### EFFECT OF COMBINED FACTORS

##### 1. Preanesthetic Fear and Premedication

Since the lowest average pulse rates were found in the children who showed no fear, and since the use of nembutal preoperatively contributes to preoperative equanimity, it is of interest to consider these two factors in combination.

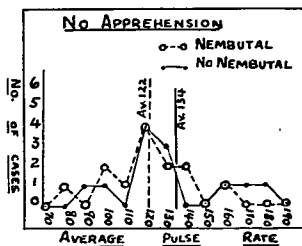


FIG. 7. Effect of nembutal premedication in nonapprehensive children: 13 cases with nembutal and 12 without nembutal.

Of the 25 children who apparently were unafraid, 13 had received nembutal and 12 had not. In the former group the average rate was 122 per minute. In the group in which no nembutal was used, the

rate was 134 per minute. It seems then, that the nembutal exerts a physiologic sedative effect on the cardiovascular system at least, beyond its psychic sedative effect (fig. 7).

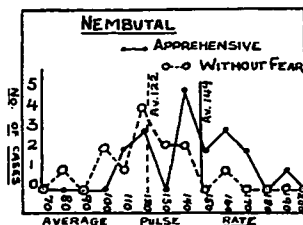


FIG. 8. Effect of apprehension in spite of nembutal premedication: 18 patients were apprehensive and 13 were not.

On the other hand, when the psychic factor is present, as in the group (31) who were apprehensive when they came to the operating room, this effect is not seen. In fact, the highest pulse rates (of any group including both anesthetic agents) were found in the 18 children who were apprehensive in spite of nembutal premedication. Perhaps this indicates that fear so acute as to be resistant to pharmacologic sedation exerts an influence on the cardiovascular mechanism which overshadows the drug effect (fig. 8).

## 2. Preanesthetic Fear and Agent

The irritating quality of ether apparently was responsible for part of the apprehension on induction, for 70 per cent of those who received it were afraid, whereas only 50 per cent of those who were anesthetized with cyclopropane were afraid.

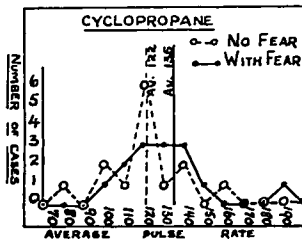


FIG. 9. Effect of apprehension in cyclopropane anesthesia: 14 children were apprehensive and 14 were not.

In the ether group, those who gave no evidence of fear had an average rate of only 134 per minute, a rate far below the general average when ether is employed.

In the cyclopropane group, those who were afraid in spite of the relatively pleasant induction it affords showed an average pulse rate of 135 per minute, well over the general average with cyclopropane of 128 per minute. Those who showed no fear had the lowest rate of any group, 122 per minute (fig. 9).

#### COMPARISON OF MAINTENANCE PULSE RATE TO OPTIMUM PULSE RATE

Merely for purposes of comparison, a rate of 120 per minute was chosen as an optimum figure. This choice is not completely empirical, since it was selected on the basis of the average nonoperative pulse rates previously determined. It was considered that an increase of about 15 per cent could reasonably be desirable as a mechanism of defense against the necessary trauma of anesthesia and surgery.

In the entire group studied, 22 per cent of the children were found to have an average maintenance pulse rate during anesthesia of 120 per minute or less.

In that group of children in whom the element of fear was not present, 10 per cent more children had optimum pulse rates (32 per cent). In the group of apprehensive children, only 10 per cent had average rates of 120 per minute or below.

Of the patients who were given nembutal preoperatively, 26 per cent had optimum rates. When it was withheld, this percentage was reduced to 18.

Of the patients who were anesthetized with cyclopropane, 35 per cent had average pulse rates of 120 per minute or less. Such rates were found in only 7.5 per cent of the cases in which ether was used.

When patients who had had nembutal came to the operating room without evidence of fear, 46 per cent of them had optimum pulse rates. If, in spite of nembutal premedication, they were apprehensive, the percentage of optimum pulse rates fell to 11.

TABLE  
COMPARISON OF PULSE RATES DURING ANESTHESIA WITH "OPTIMUM" PULSE RATES  
Percentage Having Optimum Rates  
Average of Entire Group  
22%

Factors associated with increased percentage of optimum rates		Factors associated with decreased percentage of optimum rates	
	Per cent		Per cent
Absence of fear.....	32	Apprehension.....	10
Nembutal premedication.....	26	Lack of nembutal.....	18
Nembutal plus lack of fear.....	46	Nembutal plus apprehension.....	11
Cyclopropane anesthesia.....	35	Ether anesthesia.....	7.5
Cyclopropane plus lack of fear.....	43	Cyclopropane plus fear.....	14
		Ether without apprehension.....	20
		Ether with apprehension.....	4

When ether was used, 20 per cent of the patients who apparently were unafraid had average rates at or below 120 per minute. With the same agent in the presence of apprehension, the percentage of optimum pulse rates was only 4.

With cyclopropane, when the children showed no fear, 43 per cent had rates averaging 120 per minute or less; if they were apprehensive, only 14 per cent had such rates.

### SUMMARY

The anesthetic periods of 108 children were studied, with special attention to the maintenance pulse rate and the effect upon the average rate of four factors: preanesthetic apprehension, premedication with nembutal, the agent used, and the technic of administration.

In the group who came to surgery without evidence of fear, the average maintenance pulse rate was 10 to 14 per cent lower than in the apprehensive group, and 10 per cent more of the former group had average rates at or below 120 per minute.

Premedication with nembutal, 66.6 mg., seemed to have no effect on the rates of children over 7 years, but was associated with rates averaging 11.5 per cent lower in younger children.

The use of ether was associated with higher than average pulse rates, whereas the rates with cyclopropane were generally lower.

The technic of administration appeared to have little effect, slightly higher rates being seen when the closed system was used.

Nembutal seemed to have a physiologic sedative effect independent of its psychic sedation since, in the nonapprehensive children, those who had had nembutal had 10 per cent lower rates than those who had not had nembutal.

With each of the agents used, pulse rates were lower when fear was not present, this effect being greater in the case of ether.

### CONCLUSIONS

To maintain a more nearly physiologic pulse level during anesthesia in children, it is advisable to bring the child to the operating room free from fear.

The use of preanesthetic medication with nembutal is recommended as an aid in controlling tachycardia in children during anesthesia.

For the purpose of maintaining a more physiological pulse rate, cyclopropane seems to be a better anesthetic agent than ether.

When ether must be administered, the quiet child is much more likely to have a reasonably physiologic pulse rate than is the apprehensive child.

The technic of administration of ether has little effect on the average pulse rate of children during anesthesia.

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These fellowships are open only to graduates in medicine who have completed one or more years of hospital experience as intern or resident, and awards will be made for work on problems related to anesthesia which fall largely within the following broad fields: physiology, pharmacology, biochemistry, physics and anatomy. Preference will be given to those who intend to make their careers in anesthesia. Fellowships will not be granted for training in clinical anesthesia.

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