9-1960

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Recommended Citation
Coleman, John F.; Ziegler, Robert; and Green, Edward (1960) "Pediatric Cardiac Catheterization Analgesia Or Anesthesia," Henry Ford Hospital Medical Bulletin : Vol. 8 : No. 3 , 306-309.
Available at: https://scholarlycommons.henryford.com/hfhmedjournal/vol8/iss3/5

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PEDIATRIC CARDIAC CATHETERIZATION 
ANALGESIA OR ANESTHESIA

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Cardiac catheterization has over the course of nearly fifteen years evolved from the role of investigative research to that of a frequent clinical diagnostic procedure. It must in no sense be considered a minor procedure since most patients have not only some form of heart disease but are frequently underdeveloped, irritable and cyanotic. Many are on the verge of, or in frank, congestive failure and may possess increased myocardial irritability or conduction disturbance.

The purpose of cardiac catheterization in the pediatric patient is to determine the nature of the existing lesion and the possibilities of successful surgical correction of the defect. The purpose of anesthesia or analgesia, whatever its type is primarily to facilitate cardiac catheterization . . . i.e. to afford the pediatric cardiologist a peaceful quiet subject in order that he may obtain an accurate diagnosis with the least possible hemodynamic or metabolic disturbance of the existing physiologic state. Such conditions must be obtained in a relatively poor risk patient in a darkened room in the immediate vicinity of electrical equipment posing the hazard of explosion as well as that of radiation.

Optimal preparation of children for catheter studies has been, and remains today, a subject of speculation and dispute. This statement is attested to by the wide variety of proposed solutions to this problem. Advocated techniques have ranged from the simplest to the most complex including inhalation, intravenous, subcutaneous, rectal and regional anesthetic block.

Inhalation anesthesia does fulfill the requirement of a peaceful quiet child; however, certain features of each technique have prevented its adoption as an ideal procedure. Both nitrous oxide and diethyl ether have been shown to interfere with blood gas analysis by the Van Slyke method. The latter agent, along with any explosive mixture of anesthetic gases, is excluded by the presence of electrical equipment required in the catheter room. Any technique which involves the administration of oxygen in concentrations greater or less than that occurring normally in the atmosphere will invalidate the oxygen saturation determinations made on blood from the various chambers of the heart and great vessels. The use of endotracheal techniques has been advocated in order to reduce the relative dead space, more readily control the ventilation, maintain airway patency, and allow the anesthesiologist a position perhaps a bit more remote from the radiation source.1 The problem of safely administering a general anesthetic to a child in a darkened room for an often prolonged period of time is perhaps one of the prime objections to this technique. Alterations in the metabolic rate, cardiac output, and peripheral resistance are often seen to accompany general anesthesia. In patients with moderate to severe congenital heart disease there is seen a markedly decreased tolerance to the possible complications of general anesthesia, such as anoxia, hypotension and cardiac arrhythmias.

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A simpler although not entirely satisfactory approach to the problem is that of sedation by the rectal route. Drugs so used have included both tribromethanol and thiopental.\textsuperscript{2,3} In the recommended doses this technique will usually provide a non-reacting patient for periods of one to one and one-half hours which may or may not be sufficient time for the entire procedure. Rectal sedation alone seems prone to result in an inconstant depth of anesthesia with a variable degree of respiratory depression.\textsuperscript{1} Supplemental agents or repeated doses of tribromethanol, thiopental, or meperidine may be required. Even small doses of drugs given by rectum may disturb circulatory compensation and depress respiration to such extent that normal basal conditions no longer exist. With deeper levels of sedation an airway is not assured and respiratory obstruction may occur. Rectal thiopental has been supplemented by the same agent intravenously. Such a technique admittedly results in slow recovery and a fall in arterial oxygen saturation. Rectal tribromethanol supplemented by intramuscular thiopental with hyaluronidase has had as its main complication respiratory depression.\textsuperscript{4}

With the introduction and widespread acceptance of the tranquilizing drugs in recent years, it seemed inevitable that they would also find some usage in pre-catheter management. The most frequently used combination has been meperidine, chlorpromazine, and promethazine with varying degrees of success claimed. Another proposed technique utilizes rectal thiopental followed by methorphanin (Dromoran) and levallorphan (Lorfan), phenergen, and alphaprodine (Nisentil) followed finally by bemigride (Megimide) and amiphenazole (Daptazole) with oxygen and vasopressors as needed.\textsuperscript{5} This technique requires an exact dosage and time schedule as well as a multiplicity of drugs and the presence of a trained anesthesiologist.

There is noted in recent literature what may possibly be a beginning trend back in the direction of general anesthesia. A combination of heavy premedication and the administration of trichloroethylene and compressed room air has been claimed to provide a steady constant state in the patient as well as absence of the explosion hazard or interference with blood gas analysis.\textsuperscript{6} Disadvantages of this technique include arrhythmias, tachypnea, and poor muscle relaxation. A combination of premedication and fluothane-ether azeotrope in room air has also been reported to give satisfactory results.

With the number and variety of proposed solutions to providing a quiet peaceful state in a sick infant or small child, it should be apparent that no one technique has proven universally acceptable. The role of anesthesia and, in turn, the method or technique chosen is dictated by a variety of factors: anesthetic, physiologic . . . and (far from least) the skill of the physician performing and interpreting the catheter studies.

The technique as developed in our hospital is not presented as ideal, or even an acceptable one under any and all circumstances, nor is originality claimed, but the technique has enabled the Division of Pediatric Cardiology to satisfactorily perform five thousand cardiac catheterizations since 1947 in patients ranging from two days of age to adolescence and beyond. In size, the patients have ranged from four pounds upward.
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Patients are routinely admitted on the night before the proposed procedure. Oral intake is not restricted in those infants on regular feedings. One-half to three-quarters of an hour before leaving their rooms, they are given the following drugs on a body weight basis:

Morphine Sulfate ....................... 1 mg/10 lb. of body weight
(to a maximum total dose of 4 mg.)
Phenobarbital Sodium ................... 30 mg/10 lb. of body weight

When the morphine dose exceeds four milligrams, Atropine is given to neutralize the vagotonic effects of the morphine. Doses of Atropine range from 0.15 mg. in a 40 lb. child to 0.4 mg. in one weighing 100 lbs. Meperidine (Demerol) may be substituted for morphine in the dose of 1 mg/lb. to a maximum total dose of 50-100 mg. If pulmonary hypertension is anticipated due primarily to increased pulmonary arterial resistance, meperidine has been used in preference to morphine.

Patients so premedicated are characteristically drowsy but rousable on arrival in the Catheter Clinic. Respiratory depression has only rarely been seen. For prolonged catheter studies, or in the case of a particularly robust child, supplemental sedation may be required. Intravenous secobarbital in the dose of 1 mg/lb. in gradual increments to a maximum total dose of 2 mg/lb. has proven very satisfactory. In an infant of less than two to three weeks of age or weighing less than six pounds, slightly lower doses of morphine or meperidine are sufficient. The technique just outlined has been used in nearly five thousand cases in the past thirteen years.

In this series of cases there have been fifteen instances of impaired respiration on the basis of central depression. Fourteen such cases were temporary and responded to brief assisted ventilation by either cautious manual compression of the chest or by mouth-to-mouth respiration. In most cases, adequate respiration resumed and the catheter studies proceeded. In two females morphine stimulation was seen and was readily controlled with a single dose of rectal thiopental and the catheterization was carried out as scheduled without mishap. There was one cardiac arrest and death in five thousand patients.

The results obtained with these three well-known and readily available drugs — Morphine Sulfate, Sodium Phenobarbital, and Secobarbital — can admittedly be attributed only in part to the drugs themselves. Their use in protracted catheter studies is, in fact, likely to be less satisfactory than some alternative methods. We do feel, however, that their usefulness is in direct relation to the proficiency of the pediatric cardiologist and his technical facility. The patient is usually sedated upon arrival at the clinic so that the procedure may be immediately begun. The use of the image intensifier in conjunction with the fluoroscope enables the entire procedure to be carried out in a partially lighted room which in itself appreciably cuts the elapsed time. Only one technician is routinely required to manipulate the multi-channel recording apparatus for pressure recordings and electrocardiographic monitoring. Oxygen saturation determinations are promptly completed by the micro-Van Slyke technique. Use of angio-cinefluoroscopy in conjunction with catheterization
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coupled with ultra-rapid automatic developing facilities provides accurate and im­
mediate photographic evidence of the passage of dye through the heart and great
vessels. Catheter studies usually require but from thirty to forty-five minutes from
start to finish. Angiograms add but a few minutes to this procedure. All of these
factors combine to enable a patient with congenital heart disease to have an
electrocardiogram, cardiac catheterization, and angiogram performed and interpreted
in a brief period of time.

The type of anesthesia or analgesia most satisfactory for cardiac catheterization
is determined in large part by the cardiologist, his technique and the available facilities.

We felt it of interest to anesthesiologists to report this large number of highly
successful cases in which the Department of Anesthesiology has, fortunately, played
only a minor role.

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