SEDATION OF CHILDREN FOR CARDIAC CATHETERIZATION WITH AN ATARACTIC MIXTURE¹

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A VARIETY OF METHODS for producing satisfactory conditions for diagnostic cardiac catheterization and angiocardiology have been described (1, 2, 3, 4). We consider a satisfactory state is one in which there is (a) freedom from pain, (b) absence of restlessness throughout the entire procedure, (c) no respiratory depression, and (d) sedation light enough to allow a normal response to a selective ether test. The first condition may be satisfactorily achieved by infiltration of the cut-down site with procaine HCl. The latter three conditions have been achieved, with a high degree of dependability, by the intramuscular injection of a mixture of chlorpromazine, promethazine HCl and Demerol in a series of 670 infants and children.

Prior to February, 1954, a combination of Seconal and Demerol was used for sedation at the Hospital for Sick Children, Toronto. The deficiencies of this method were (a) an undependable degree of sedation, (b) restless during the study, and (c) a shocked appearance in many patients at the termination of catheterization, despite adequate blood replacement. In view of our satisfying experience with chlorpromazine and promethazine as preoperative sedatives (5), we considered that these agents might find a place in the sedation of patients for cardiac catheterization.

Chlorpromazine and promethazine given singly, together, and with various amounts of Demerol were administered to 80 patients. The ataractics alone improved the condition of patients at the termination of catheterization, but did not provide satisfactory conditions during the studies. The combination of Demerol with the ataractics (our "Catheter Mixtures") provided both optimum working conditions and a satisfactory post-catheter condition (Table I). The most dependable results were obtained with Catheter Mixture Number Three, CM₃, which contains the highest concentration of Demerol.

TABLE I
COMPOSITION OF "CATHETER MIXTURES"

	Proportions by volume			Mgm /cc of mixture		
	Chlorpromazine	Promethazine	Demerol	Chlorpromazine	Promethazine	Demerol
CM ₁ ^a	1	1	: 1	8 3	8 3	16 7
CM ₂	2	2	: 3	7 1	7 1	21 3
CM ₃	1	1	: 2	6 25	6 25	25 0

^aCM₁ = Laborit's Mixture One (M₁) (7)

CM₃ has been used on 670 patients, ranging in age from 4 days to 16 years; 43 per cent of the patients in the series were under one year of age.

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<i>Age</i>	<i>Number of cases</i>
Under 1 month	35
1-11 months	258
1-4 years	177
5-9 years	135
10 years and over	65
	<hr/> 670

DOSAGE

CM₃ was administered intramuscularly one hour before catheterization. The dose was based on the general condition of the patient and the degree of cyanosis. Acyanotic children in good general condition received 1 cc. of the mixture for each 20 pounds of body weight. In generally debilitated or cyanotic patients the dose was reduced by approximately 25 per cent. Large intramuscular injections are usually painful, and older patients usually require less sedation and are more co-operative. Accordingly, the dose was restricted to 1.5 cc. in patients weighing more than 30 pounds. When additional sedation was required, 25-50 per cent of the intramuscular dose was injected intravenously via the catheter. Only one patient required repeated supplementation during catheterization.

PRE-CATHETER STATE AND COMPLICATIONS

The pre-catheter conditions of each candidate was judged to be "good," "fair," or "poor" on the basis of (*a*) general nutrition and weight for age, (*b*) cardiac size, (*c*) presence of failure, (*d*) the degree of oxygen unsaturation at rest, and (*e*) the decrease in saturation accompanying exercise or crying. Using these criteria we judged that 214 patients were in good condition, 366 patients in fair condition, and 90 in poor condition.

Three subjects developed serious respiratory depression within one hour of the administration of the mixture. Two were cyanotic infants who received CM₃ on the basis of 1 cc./20 lb. The course of one of these patients is described under the section on mortality. The other patient responded promptly to treatment with Nalline.

Such reactions in cyanotic infants, we now appreciate, can be avoided by reducing the dose of CM₃ by 20-50 per cent depending on the degree of cyanosis.

A third non-cyanotic child weighing 43 lb. received 3.5 cc. of CM₃ in error and developed marked respiratory depression. Catheterization was postponed until respiration became normal about three hours later.

EFFICACY OF SEDATION

The majority of patients, 504, were well sedated and tolerated the entire procedure without becoming restless. Restlessness during the cut-down and insertion of catheter was encountered in 166 patients, 122 of whom became quiet and co-operative immediately following the insertion of the catheter. The remain-

ing 44 continued to cry and move about. Of these patients 26 were supplemented with small additions of CM_3 via the catheter and became well sedated; the remaining 18 (27 per cent) were not supplemented and constitute the failures in sedation encountered using CM_3 . These cases occurred early in the series before injection through the catheter was considered to be a safe procedure.

One child, who had suffered a recent head injury, was extremely agitated before sedation and required three supplements during a study lasting two hours.

The duration of efficacy of CM_3 may be inferred from the following figures

<i>Duration</i>	<i>Number of cases</i>
Under 1 hour	95
1-1½ hours	273
1½-2 hours	214
2-2½ hours	66
2½-3 hours	19
Over 3 hours	3
	<hr/> 670

The initial injection was quite adequate for times up to 3½ hours. The median duration of time for catheterization for the series was 81 minutes.

CONDITION DURING CATHETERIZATION

The majority of patients dozed from time to time during the procedure. They could always be easily awakened, and the older patients were able to chat with the attending nurses. Many patients exhibited a characteristic "smacking" movement of the lower lip. This phenomenon is an indication of excellent sedation, for all patients exhibiting this sign were completely free from all restlessness yet had no respiratory depression.

Depressed breathing did occur in one patient, a 20-lb infant, following the intravenous injection of 0.5 cc. of CM_3 . The depression was rapidly corrected by the injection of 0.12 cc. Nalline.

Although some patients exhibited a fall of 5-10 mm Hg in mean pressure, the systemic blood pressure was not consistently lowered. Pulmonary artery pressures in a series of patients catheterized without sedation changed by only a few mm. Hg when CM_3 was injected intravenously (6).

The administration of CM_3 did not protect the heart against the occurrence of irregularities incident to manipulation of the catheter within its chambers. Extrasystoles, singly or in groups, occurred in 500 patients. Some degree of heart block was observed in 98 patients, and brief periods of tachycardia occurred in 59.

In two patients a supraventricular tachycardia developed and persisted despite withdrawal of the catheter into the vena cava. Both patients responded rapidly to orbital pressure. One developed auricular fibrillation requiring treatment with digoxin. Another patient suffered a period of breath-holding following the injection of ether for a selective ether test. He responded to a brief period of artificial ventilation with oxygen.

Fatalities occurring during catheterization are described in the section on mortality.

POST-CATHETER CONDITION AND COMPLICATIONS

At the termination of the study the general condition of each child was assessed as being good, fair, or poor. This assessment was based on the presence of (a) deterioration from the pre-catheter condition, (b) shock, (c) change in degree of cyanosis, (d) arrhythmia, and (e) vomiting. Using these criteria 625 patients were judged to be in good condition; 34 were in fair, and 11 in poor condition. Only 17 patients appeared shocked. Their condition became good following the infusion of small volumes of whole blood (Table II).

TABLE II
CONDITION AT TERMINATION OF STUDY

Condition	Before transfusion	Number transfused	After transfusion	
Good	625		642	95.8%
Fair	34	16	18	2.7%
Poor	11	1	10	1.5%

In 262 patients a selective angio-cardiogram was performed as the last step of the catheter study. Nine patients in otherwise good condition suffered complications following this procedure. Tachycardia occurred in two patients. Cyanosis deepened in two patients and apnoea occurred in another two. All four children responded quickly to the administration of Coramine. Three patients vomited following the injection of the contrast media.

On return to the ward the majority of patients slept for several hours unless aroused. They were able to take fluids when awakened, but would then fall asleep again if left undisturbed.

Fatalities occurring in the post-catheter period are described in the next section.

MORTALITY

Of the 670 subjects who received CM₃ 4 died at or shortly after cardiac catheterization. All were given the full dose of the mixture calculated on a weight basis prior to the study.

The only death directly attributable to the mixture was that of a gravely ill cyanotic infant aged two months who was in heart failure from a true truncus arteriosus. She developed gasping respirations one hour after the administration of the mixture. Despite her poor condition a rapid study was planned. Bradycardia developed when the catheter entered the right heart whereupon the study was abandoned. The infant died twenty minutes after returning to the ward. In retrospect, this infant should not have received the full dose of CM₃, and Nalline might have revived her temporarily.

The other patients were all well sedated. One infant aged nine days with severe simple pulmonary stenosis died from the inadvertent injection of the contrast media through a catheter wedged in the coronary sinus.

Another infant aged two months with idiopathic hypertrophy of the left ventricle developed bradycardia leading to a fatal arrest during the study.

The fourth death was that of an infant aged seven months with severe simple pulmonary stenosis whose catheterization was complicated by a paroxysm of supraventricular tachycardia. This was terminated promptly by pressure on the eyeball. The infant was returned to the ward in good condition, appeared well an hour and a half after the study, but was found dead in her crib one hour later.

Two other patients are of interest. One was a seven-day-old infant who was catheterized without preliminary sedation because of poor general condition. Restlessness developed just as the catheter was passed through an interventricular defect into the root of the aorta. A diluted mixture of 0.04 cc. CM₃ in saline was then injected through the catheter. Cardiac arrest occurred immediately. Massage was instituted within two minutes and normal cardiac activity returned within fourteen minutes. The infant recovered completely, but died two weeks later at the time of open heart surgery.

One eleven-year-old boy with a complex malformation producing marked cyanosis underwent a study lasting two hours without incident under CM₃ sedation. A few days later a catheter was inserted again, but this time without sedation for the purpose of carrying out a selective angio-cardiogram. Fatal arrhythmias developed when the catheter reached the right atrium.

DISCUSSION

Where general anaesthesia is not used for cardiac catheterization of infants, and children, different methods of sedation for maintaining a steady state have been employed. Inadequate sedation with resulting restlessness and crying is the chief problem encountered. The use of CM₃ by intramuscular injection has almost completely overcome this problem. Since individual tolerance to the mixture varies, employing an arbitrary schedule of dosage will result in a certain number of patients being over-sedated while others will require additional amounts of the drug to achieve satisfactory sedation. In view of this variation the safest method of sedation is (a) to deliberately under-sedate initially, and (b) to supplement with small increments of the mixture via the catheter.

The mixture can provide optimum conditions for cardiac catheterization in all patients in the younger age group providing that certain important precautions are observed. Firstly, in cyanotic infants or infants in grave condition the initial dose should be reduced by 20–50 per cent of the arbitrary dose depending on the degree of cyanosis and debility. Secondly, should supplementation become necessary, any additional quantity of CM₃ should be given slowly in dilute solution through a catheter situated no further centrally than a vena cava.

The mixture has also been used as sedation for 203 patients undergoing venous angiograms, 13 undergoing hepatic wedge pressure determinations, and for a few receiving EEG investigations. While the data for these patients is not presented, the effectiveness of the sedation has satisfactorily paralleled the results in the catheter series reported above.

SUMMARY

A mixture of chlorpromazine, promethazine and Demerol was administered intramuscularly as sedation to 670 children undergoing cardiac catheterization.

With certain modifications, an arbitrary dosage schedule of 1 cc/20 lb. was employed. Infants in poor condition or with cyanosis received 50–80 per cent of this arbitrary dose. A maximum dose of 15 cc was used in patients weighing more than 30 pounds. Those patients who were insufficiently sedated were supplemented with small diluted quantities of the mixture given via the catheter. Such injections should be made into a vena cava rather than into a chamber of the heart.

Details of four deaths occurring in the pre-catheter and post-catheter periods are presented.

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RÉSUMÉ

Pour permettre de leur faire un cathétérisme cardiaque, on a donné à 670 malades dont l'âge variait de 4 jours à 16 ans, un mélange de chlorpromazine, du chlorhydrate de prométhazine et du Demerol. Ce mélange (une partie de chlorhydrate de prométhazine et une partie de chlorpromazine avec 2 parties de Demerol) a été donné en injection intramusculaire à raison de 1 ml par 20 livres de poids sans toutefois dépasser 2 ml. Chez 26 malades, après l'introduction du cathéter, on a donné des doses fractionnées par voie endoveineuse. Avant le cathétérisme, l'état des malades était bon chez 31.9% des cas, passable chez 54.6% et mauvais chez 13.5%. Chez 97.3% des cas, cette sédation a été adéquate et elle ne l'a pas été dans un pourcentage de 2.7%. Au delà de 70% de ces examens ont duré de une heure à deux heures. À la fin de l'examen, 95.8% des malades étaient en bon état. Les arythmies les plus fréquemment observées furent des extrasystoles, des blocages nerveux et de la tachycardie paroxystique.

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