ANESTHESIA FOR CARDIAC CATHETERIZATION
IN INFANTS AND CHILDREN

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THE exact diagnosis of congenital malformations of the heart and
great vessels is mandatory for their proper surgical treatment. The
taxation of straining, crying and concomitant breath-holding during
the diagnostic procedure of cardiac catheterization in infants and chil-
dren may precipitate heart failure in these patients. In addition, the
oxygen determinations obtained during these periods of stress are
misleading and valueless. We have, therefore, concluded that infants
and children, from birth to twelve years, require loss of consciousness
for cardiac catheterization.

The problems these patients present to the anesthesiologist are
unique. All have a deranged cardiovascular system; all are young;
some are below normal development for their age; and many have had
at least one episode of cardiac decompensation. Added to the inherent
risks of size and incapacitation are the dangers of working in a flur-
scopy room and the requirement not to use oxygen inhalation during
the study.

CLINICAL SERIES

When our series was started in 1948, the only preanesthetic medica-
tion ordered was atropine sulfate. Basal narcosis was maintained
with a 10 per cent solution of thiopental sodium, administered rectally.
The calculated initial dosage was 20 mg. per pound of body weight.
One half the initial dosage was repeated if the child moved or cried.
This proved inadequate for three reasons: first, we were unable to
avoid the expulsion of the solution from the rectum; second, the aver-
age duration of sleep after a second instillation was six hours; and
third, the average dosage required was 44 mg. per pound of body
weight, rather than the calculated 20 mg. To try to reduce the total
amount of thiobarbiturate instilled rectally, thus decreasing the post-
anesthetic recovery time, and to decrease the incidence of undesired
bowel movements, a Foley catheter was inserted into the rectum, the
cuff filled with air and then clamped prior to the injection of the basal
solution. This achieved success in eliminating evacuation of the

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bowels, but did not decrease the need for repeated dosage of the barbiturates to control the movement of the patient—perhaps owing to the increased pain from the Foley bulb within the rectum. We found the average time to produce basal hypnosis following rectal instillation of thiopental sodium to be twenty-seven minutes. Two hundred seventy-two cases were managed with rectal barbiturates. There were no fatalities in this group. Venospasm was a frequent complaint of the pediatric cardiologist. We interpreted this to be a result of direct irritation of the catheter to the vein.

Avertin® fluid was instilled rectally in the next series of 117 cases. Preliminary medication was ordered one hour prior to the scheduled time of anesthesia and consisted of atropine sulfate as advocated by Leigh and Belton (1). The initial dose of tribromethanol and amylene hydrate was 90 mg. per kg. of body weight. Two volumes of the solution were prepared, so that fractional or supplemental doses could be administered as needed. A Foley catheter with inflatable bag was used to diminish the incidence of bowel evacuation.

The average dose of Avertin fluid required in the 117 cases was 122 mg., much higher (33 per cent) than our calculated dose. Venospasm persisted in this series of infants and children. The onset of hypnosis was twenty-two minutes (five minutes shorter than with the rectal barbiturates), and local infiltration with procaine was required for actual venous cannulation. The average sleep, following onset of narcosis, was seven hours. This was one hour longer than with the previous series. The pulse rate was increased 12 per cent, there was decrease in systolic blood pressure, and respiratory depression was markedly increased. There were two deaths attributable to anesthetic overdosage with respiratory depression. Neither patient regained consciousness after the effect of Avertin fluid was manifest.

A resident* in anesthesiology at Hahnemann Hospital suggested that an intramuscular solution of 5 per cent thiopental sodium be used to produce hypnosis. To the stock solution of 1 Gm. was added 1,500 turbidity units of hyaluronidase. An initial dosage of 6 to 8 mg. per pound of body weight was injected deeply into the gluteus maximus muscle. Sleep occurred in sixteen minutes and lasted sixty-five minutes. If the catheterization was not completed in that interval of time, a second intramuscular instillation was required. The supplemental dose was 5 mg. per pound of body weight. The period of somnolence was increased to two and one-half hours. More recently, we have supplemented with doses of 2 mg. per pound and believe that the period of somnolence was lessened thereby. Hyaluronidase increased the onset of sleep, but decreased the duration of action.

Thiamylal sodium (Surital®), 5 per cent solution, was used in alternate cases in an effort to compare its effect with thiopental sodium. Three hundred eleven infants and children from the ages of three

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weeks to twelve years were studied. The period of narcosis was found to be identical, two and one-half hours. The only variation was that a slightly larger amount of thiopental sodium, 10½ mg. per pound, was required in comparison with 9½ mg. of thiamylal sodium. This difference is not statistically significant. One hundred fifty-six children received thiopental sodium, and 155 thiamylal sodium.

Meperidine hydrochloride, 1 mg. per pound of body weight, and atropine sulfate are ordered as preliminary medication in all cases at the present time. It has proven of value in decreasing the total amount of barbiturate required, and has decreased the duration of crying and stress prior to loss of consciousness. Meperidine hydrochloride is given in equally divided doses, ninety and forty-five minutes prior to the scheduled hour of induction. We believe using the divided dosage to be effective in combatting respiratory depression from preliminary medication. Atropine sulfate is given with the second dose.

We believe intramuscular barbiturates to be indicated in infants six years and younger. We have encountered no tissue damage (slough or abscess formation) in our series if the drug was deposited intramuscularly. We have seen tissue damage from ultrashort acting barbiturates deposited in superficial tissues—as when a needle deviated from a vein. It should also be noted that the barbiturate injected improperly in the buttock (not in the upper outer quadrant) may be placed close to the sciatic nerve, causing temporary or permanent paralysis. One of us has seen such a case in consultation.

Although, as a general rule, we use intramuscular ultrashort acting barbiturates in children under six, we usually inspect the arms for veins, and in quiet children with good veins, the intravenous route is employed because of the greater flexibility of dosage. In the smallest children, we think it important that 1½ per cent solution be used intravenously.

A convenient route of administration of thiobarbiturate is provided while the catheter is still within the vein, especially for supplementation toward the end of a procedure begun with intramuscular thiobarbiturates. We use dilute solutions and rigorously refrain from injecting barbiturates when the tip of the catheter is in the ventricle or low in the atrium, usually doing so only when the catheter is in one of the venae cavae or high in the right atrium, because we believe that the concentration of the ultrashort acting barbiturates is too great, resulting in profound respiratory depression.

Children, six years of age or older, receive meperidine hydrochloride, 1 mg. per pound of body weight, in equally divided doses, not to exceed 100 mg. These children have sleep induced by intravenous injection of a 2½ per cent solution of an ultrashort acting sodium barbiturate. Three hundred eighteen children have been managed by the intravenous technique. The cases have again been equally divided between thiopental sodium and thiamylal sodium. We have been unable
to find any major variations between these agents when used intrave-
ously; this is in agreement with the findings of Tovell et al. (2).

Respiratory depression is the major anesthetic complication seen
in this series. In addition, apnea of short duration has occurred in
about 1 per cent of cases. Partial respiratory obstruction is seen oc-
casionally, owing either to secretions or to the relaxed jaw. Laryn-
gospasm has been notably absent.

The hazard of relatively prolonged anesthetic time probably is in-
herent in any procedure requiring the use of nonvolatile anesthetic
agents in children. Meticulous efforts to minimize dosage, adequate
premedication and facility in catheterization techniques have been our
most effective aids in this problem.

Transitory cardiac arrhythmias occur in virtually all cases. These
are primarily due to mechanical irritation from the catheter. They
occur most commonly when the catheter tip touches the septum or ven-
tricular wall. They are regularly produced when the catheter nearly
or completely occludes a valve orifice or the lumen of the coronary
sinus, or when traction is produced with the catheter.

Cardiac activity is continuously monitored on the electrocardio-
scope during the catheterization. We believe very strongly, however,
that continuous palpation of the pulse by the anesthesiologist is man-
datory, both as a check and as an additional safeguard. We have
often noted that various manipulations may produce reductions in
cardiac output of startling degree without alteration of the rhythm of
the heart. The heart sounds are monitored as advocated by Cullen
(3), by continuous auscultation prior to the use of fluoroscopy.

**DISCUSSION OF RESULTS**

The average sleeping time after cardiac catheterization is shown in
table 1 from the 1,018 cases surveyed. Three deaths occurred, two
after having received Avertin fluid, and one following intravenous
thiamylal sodium. Since this amounts to a death rate of three per
thousand, which is probably three times greater than the death rate
from right heart catheterization itself, the addition of anesthesia to the

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>AVERAGE PERIODS OF SLEEP AFTER CATHETERIZATION</th>
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<tbody>
<tr>
<td>Agent</td>
<td>Route</td>
</tr>
<tr>
<td>Thiopental sodium</td>
<td>Rectal</td>
</tr>
<tr>
<td>Avertin fluid</td>
<td>Rectal</td>
</tr>
<tr>
<td>Thiopental sodium</td>
<td>Intramuscular</td>
</tr>
<tr>
<td>Thiamylal sodium</td>
<td>Intramuscular</td>
</tr>
<tr>
<td>Thiopental sodium</td>
<td>Intravenous</td>
</tr>
<tr>
<td>Thiamylal sodium</td>
<td>Intravenous</td>
</tr>
<tr>
<td>Total</td>
<td>1018 cases</td>
</tr>
</tbody>
</table>
procedure is not to be taken lightly. Since the procedure cannot be accomplished, however, without anesthesia in most children, it is deemed entirely justified where diagnosis by other means cannot be made with certainty.

**Summary and Conclusions**

Results from a series of 1,018 anesthetics for cardiac catheterization in infants and children have been presented. Complications and average sleeping time have been compared using intravenous, rectal and intramuscular routes for producing narcosis.

Intramuscular barbiturates have proved a satisfactory mode of producing basal narcosis. There have been no untoward tissue reactions when the barbiturates have been instilled into deep muscles.

Children old enough to allow satisfactory venipunctures were best controlled with a 2½ per cent solution of thiopental sodium or thiamylal sodium.

Respiratory depression was the most common anesthetic complication. A supply of oxygen and a method of administration of oxygen should be readily available during the course of anesthesia. Procaine hydrochloride should be infiltrated into the skin for control of pain from venous cannulation with the cardiac catheter.

**REFERENCES**