External Electrical Termination of Supraventricular Arrhythmias in Congenital Heart Disease

By Milton H. Paul, M.D., and Robert A. Miller, M.D.

The technic of external electrical countershock for the emergency termination of ventricular fibrillation has been receiving wide application since the reports of Zoll and associates and Kouwenhoven and associates. The deliberate, elective application of this form of therapy has recently been reported for the termination of ventricular tachycardia.

With external electrical countershock we have now been able to terminate electively and instantaneously, persistent supraventricular arrhythmias in children with congenital heart disease in whom the arrhythmias were resulting in serious complications.

Earlier experimental work in the closed-chest animal preparation had indicated that any form of tachycardia, supraventricular, nodal, or ventricular in origin, can be terminated by external countershock techniques.

Apparatus and Technic

Standard equipment for electrical countershock was used with the application of alternating current.

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Figure 1
Electrocardiograms obtained prior to onset of supraventricular arrhythmias.
EXTERNAL TERMINATION OF SUPRAVENTRICULAR ARRHYTHMIA

Table 1

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>S.S.</th>
<th>K.McG.</th>
<th>N.B.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tricuspid atresia</td>
<td>15</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>3+</td>
<td>3+</td>
<td>1+</td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) A-P anastomosis (5 yr.)</td>
<td></td>
<td>(1) A-P anastomosis (1 mo.)</td>
<td>(1) Open-heart total surgical correction (9 yr.)</td>
</tr>
<tr>
<td>(2) Atrial septal defect enlargement (15 yr.)</td>
<td></td>
<td>(2) Revision of A-P anastomosis (9 yr.)</td>
<td></td>
</tr>
<tr>
<td>Previous arrhythmias</td>
<td>Multiple episodes</td>
<td>Multiple episodes</td>
<td>None</td>
</tr>
<tr>
<td>Duration of arrhythmia from onset to termination (days)</td>
<td>16</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Medications</td>
<td>Digitalis, quinidine</td>
<td>Digitalis, quinidine</td>
<td>Digitalis, quinidine</td>
</tr>
<tr>
<td>Countershock (volts)</td>
<td>1 (350)</td>
<td>1 (350)</td>
<td>1 (350)</td>
</tr>
</tbody>
</table>

Figure 2

Roentgenograms taken shortly before application of countershock therapy.
Clinical Material and Results

Table 1 summarizes the pertinent clinical observations on these patients. Figure 1 illustrates the electrocardiogram of each patient prior to the onset of the supraventricular arrhythmia and figure 2 illustrates the chest x-ray obtained just prior to the application of elective countershock therapy.

Patients S.S. and K. McG. had tricuspid atresia with pulmonary stenosis and in both aortic-pulmonary shunts were produced with good results earlier in life.

In our first patient, S.S., atrial fibrillation occurred following a second surgical procedure to open the interatrial septum widely. The arrhythmia persisted with fibrillation-flutter patterns being recorded for 16 days with a progressively deteriorating clinical course (fig. 3A). Quinidine was used with digitalis during this period, but severe systemic and cardiovascular toxic reactions resulted without termination of the arrhythmia (fig. 3B). The child was then anesthetized and one electric shock of 350 volts and of 0.15-second duration was applied to the anterior chest wall with immediate reversion to normal sinus rhythm (fig. 3C and D). There was then marked clinical improvement, and the child has been maintained on digoxin therapy with normal sinus rhythm until the present time (6 months).
In the second patient, K. McG., with tricuspid atresia and a previous aortic-pulmonary anastomosis, atrial fibrillation and flutter was associated with increasing congestive heart failure and a deteriorating clinical status. In this child the flutter (fig. 4A) persisted for approximately 2 weeks despite drug therapy, and, in view of the progressively poor clinical status, elective electrical termination was performed as in the previous child (fig. 4B and C). For the following 24 hours the child appeared to be in a satisfactory condition with normal sinus rhythm. Then, however, episodes of ventricular tachycardia occurred, probably associated with digitalis intoxication, and the child died (figs. 5D to G).

A third patient, N.B., age 8 years, with total anomalous pulmonary venous drainage entering the coronary sinus, underwent open-heart complete correction of this anomaly. The postoperative course was uneventful for 10 days. Then, however, increasing congestive heart failure was noticed. An electrocardiogram demonstrated atrial flutter with an atrial rate of 400 per minute and a ventricular rate of 150 per minute (fig. 6A). Quinidine therapy in association with digitalis was undertaken with some decrease in the ventricular rate, but widening of the QRS complex led us to discontinue the drug. The child was anesthetized and elective external termination of the arrhythmia was carried out with a single countershock (fig. 6B and C). This patient also has remained without recurrent arrhythmia to this date (4 months).

A fourth patient, P.K., with probable con-
Figure 7
P.K. (A) atrial fibrillation-flutter, (B, C, and D) countershock (350, 450, 550 V.) without significant effect on the arrhythmia.

External electrical termination of ventricular fibrillation in conjunction with external cardiac massage provides a most effective means of emergency cardiac resuscitation. The newly described technic of elective external termination of ventricular, and now supraventricular, cardiac arrhythmias permits restoration of normal sinus rhythm to be effected instantaneously when the arrhythmia may be significantly restricting the functional capacity of the heart. Paroxysmal supraventricular tachycardias are not uncommon occurrences in pediatric cardiology, but persistent arrhythmias that fail to respond to drug therapy are rare. When they persist, as in our patients, there is often massive dilatation and hypertrophy of the cardiac chambers.

The technic of external countershock appears to be a relatively safe procedure for elective termination of serious arrhythmias and it avoids the not infrequent toxic reactions to drug therapy. Although more extensive experience will be necessary, this technic appears to have wide application to supraventricular as well as ventricular arrhythmias and may particularly be of value in the problem of persistent atrial fibrillation and flutter in the adult patient with cardiovascular disease.

Summary
Persistent supraventricular arrhythmias of the flutter or fibrillation-flutter type have been terminated by elective external electric countershock in three patients after drug therapy had been unsuccessful.

It is suggested that this technic is a relatively safe and effective treatment for supraventricular as well as ventricular arrhythmias when anti-arrhythmic drugs have proved ineffective.

References


**Basic Versus Applied Research**

Basic research is the never-ending search for better understanding of man himself and of the total world, animate and inanimate, in which he lives. The drive which stimulates basic research is man's insatiable curiosity concerning the unknown, and the intellectual and aesthetic satisfaction that comes from understanding.

There is an intimate and mutually helpful interrelation between basic research and applied research, the latter being research which is directed toward practical ends. Applied research may necessitate or involve basic research; for, in the solution of practical problems, new knowledge may be found necessary or may be incidentally uncovered. Basic research stimulates applied research; for, it is a striking fact of experience that new knowledge, however esoteric it may seem when first discovered, almost always turns out to be of practical use.

Although interrelated and sometimes overlapping, there are significant distinctions between basic research and applied research. The applied investigator usually has to stick reasonably close to his assigned purpose. He may have to abandon an interesting trail because it has become clear that it will not lead to the solution of the particular assigned problem. The basic researcher, on the other hand, is on his own, free to investigate what appeals to him. This does not mean that the basic researcher wanders aimlessly, but it does mean that he is controlled only by the discipline of his methods.

Applied research is often, if not usually, aimed at producing new or better products or processes. Basic research is aimed at producing new ideas.

Knowledge essentially always turns out to be "practical." But the knowledge involved in applied research is likely to be applicable to definite and relatively confined problems. The knowledge which basic research seeks is knowledge which may be broadly applied to nature as a whole.

The basic researcher is the scientist who himself makes the hard choices between what he will continue to do and what he will stop doing.—Warren Weaver, M.D. *American Scientist* 47: 208A, 1959.
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