The Use of Hypothermia After Cardiac Arrest......Page 423

Journal of the International Anesthesia Research Society

Volume 38, Number 6 November-December, 1959

Printed in U.S.A.
THE USE OF HYPOTHERMIA AFTER CARDIAC ARREST

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ADOLPH J. YATES, M.D.

ALL TOO FREQUENTLY the establishment of adequate circulation after cardiac arrest does not result in a salvaged patient. The damage caused to the central nervous system by hypoxia progresses, with continued deterioration and death.

Williams and Spencer,1 in their report of four cases of cardiac arrest with severe neurological damage treated with hypothermia, reviewed the literature concerning the pathology underlying the clinical picture resulting from cerebral hypoxia and the rationale for utilizing hypothermia in its treatment. This may be summarized briefly as follows: There is direct nerve cell injury with secondary brain swelling.2-4 The increase in brain volume, exceeding the capacity of the cranium, leads to shifts in brain position, brain stem herniation and resultant obstruction of cerebrospinal fluid movement, direct neuronal injury, and small midbrain hemorrhages. These produce further local ischemia and vascular injury, with even more swelling and the associated clinical signs.5-6

Hypothermia has been shown to protect the brain against anoxia.7-11 There is a reduction in the cerebral oxygen consumption and cerebral blood flow with body cooling.9, 12-14 It reduces normal brain volume15, 16 and reduces brain swelling caused by tumor.6, 8 Patients with severe head injuries have been reported to have benefited from hypothermia.7, 17 Experimentally, hypothermia protects against infarction due to severance of the middle cerebral artery, if cooling is induced within 15 minutes after severing the artery.18 The value of hypothermia is demonstrated in dogs subjected to circulatory arrest for 10 minutes and then cooled.18 Recently it was shown that prednisolone and hypothermia combined produced a significant decrease in mortality and an increase in survival time in rabbits subjected to a standard cerebral injury.14

Central nervous system damage after cardiac arrest may be considered an injury similar to those produced experimentally. It appears rational, therefore, to use hypothermia in the treat-

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ment of the patient who has suffered cardiac arrest. A review of 27 instances of cardiac arrest which occurred at the Johns Hopkins Hospital from May 1, 1956, to November 1, 1956, has yielded some data which attest to the value of using hypothermia as a therapeutic measure in the immediate post-cardiac-arrest period.

**MATERIAL**

In order to limit the cases to what

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**About the Authors**

★ **DONALD W. BENSON, M.D.,** is Professor of Anesthesiology at Johns Hopkins University School of Medicine, Baltimore, Maryland. He received his medical degree, served a residency in anesthesiology and received a Ph.D. degree in Pharmacology at the University of Chicago. From 1943 to 1946 he served in the USNR as a Line Officer. He is President-elect of the Maryland Society of Anesthesiologists. His hobby is music, and he and his wife, Marjorie, are the parents of two girls and a boy.

★ **G. RAINLEY WILLIAMS, JR., M.D.,** is now Assistant Professor of Surgery at the University of Oklahoma School of Medicine. He received his medical education at the University of Texas, Austin, Texas, and Northwestern University Medical School, Chicago, Illinois, receiving the degrees of B.S., B.Med. and M.D. Dr. Williams was in military service from July, 1944 to November, 1945 as a member of the U.S. Navy V-12. He served again in the U.S. Army Medical Service as 1st Lieutenant from 1953 to 1955. He has had articles published on cardiovascular problems. Dr. Williams and his wife, Martha Alden Williams, have three children.

★ **FRANK COLE SPENCER, M.D.,** Surgeon and Associate Professor of Surgery at Johns Hopkins University, attended North Texas State University, Denton, Texas, receiving the B.S. degree, and Vanderbilt University School of Medicine, Nashville, Tennessee. He was a Lieutenant in the Medical Corps, U.S. Navy, from August, 1951 to July, 1953. Dr. Spencer was a John & Mary R. Markle Scholar in Medical Science, and he also received the Founder’s Medal Scholarship Award from Vanderbilt University School of Medicine in 1947.

★ **ADOLPH JOSEPH YATES, M.D.,** is at present General Surgical Resident at The University of Pittsburgh Medical Center Hospitals and Teaching Fellow in General Surgery of the faculty of the University of Pittsburgh Medical School. He attended The Johns Hopkins University, receiving the A.B. degree, and The Johns Hopkins University School of Medicine, from which he obtained his medical degree. He served a straight surgical internship and surgical residency at The Johns Hopkins Hospital, and at the present time he is serving a surgical residency at The University of Pittsburgh Medical Center. He has held a medical licensure in the State of Maryland since 1957.
### DATA FROM TWENTY-SEVEN CASES OF CARDIAC ARREST

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Sex</th>
<th>Site of arrest and date</th>
<th>Operation or episode at arrest</th>
<th>Neurological status after arrest</th>
<th>Interval from arrest to hypothermia</th>
<th>Average temperature during hypothermia, Centigrade</th>
<th>Duration of hypothermia, hr.</th>
<th>Outcome</th>
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<tbody>
<tr>
<td>1</td>
<td>1½</td>
<td>F</td>
<td>Operating room 4/7/58</td>
<td>General anesthesia; debridement of burn</td>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
<td>Died 4 days</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>F</td>
<td>Operating room 6/23/56</td>
<td>General anesthesia; appendectomy</td>
<td>Ineffectual massage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>M</td>
<td>Operating room 12/23/57</td>
<td>General anesthesia; stab wound of the chest</td>
<td>Ineffectual massage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>41</td>
<td>M</td>
<td>Recovery room 9/11/57</td>
<td>Postpneumonectomy, 23 hr.</td>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
<td>Died 4 hr.</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>M</td>
<td>Recovery room 12/22/57</td>
<td>Postpyelolithotomy, 15 hr.</td>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
<td>Died 2 hr.</td>
</tr>
<tr>
<td>6</td>
<td>56</td>
<td>M</td>
<td>Recovery room 6/13/57</td>
<td>Ruptured aortic aneurysm</td>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
<td>Died 35 days; never responded</td>
</tr>
<tr>
<td>7</td>
<td>70</td>
<td>M</td>
<td>Recovery room 10/31/56</td>
<td>After suturing, bleeding ulcer, 2 hr.</td>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td>Died 7 days; progressive deterioration</td>
</tr>
<tr>
<td>8</td>
<td>74</td>
<td>M</td>
<td>Anesthesia room 11/4/56</td>
<td>Acute cholecystitis, peritonitis</td>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td>Died 13 days; pneumonia and brain damage</td>
</tr>
<tr>
<td>9</td>
<td>13</td>
<td>M</td>
<td>Recovery room 5/16/58</td>
<td>Exploratory laparatomy on arrival in recovery room</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>10</td>
<td>33</td>
<td>M</td>
<td>Operating room 12/15/56</td>
<td>General anesthesia; evacuation of traumatic hemotherax</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>11</td>
<td>35</td>
<td>M</td>
<td>Anesthesia room 9/15/58</td>
<td>Anesthesia induction; perforated ulcer</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td>Lived; no residual</td>
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<tr>
<td>12</td>
<td>40</td>
<td>M</td>
<td>Operating room 5/22/56</td>
<td>General anesthesia; attempted pneumonectomy</td>
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<td></td>
<td></td>
<td></td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>13</td>
<td>58</td>
<td>M</td>
<td>Anesthesia room 4/1/57</td>
<td>Anesthesia induction; ruptured aortic aneurysm</td>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td>Lived; no residual</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
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<th>Operation or episode at arrest</th>
<th>Neurological status after arrest</th>
<th>Interval from arrest to hypothermia</th>
<th>Average temperature during hypothermia, Centigrade</th>
<th>Duration of hypothermia, hr.</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>64</td>
<td>F</td>
<td>Recovery room 6/24/57</td>
<td>Postcholecystectomy, 4 hr.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>15</td>
<td>84</td>
<td>F</td>
<td>Operating room 11/21/57</td>
<td>General anesthesia; incarcerated hernia</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>F</td>
<td>Bronchoscopy 11/28/57</td>
<td>Bronchoscopy; local anesthesia</td>
<td>Severe</td>
<td>1 hr.</td>
<td>30°</td>
<td>3</td>
<td>Died 4 hr.</td>
</tr>
<tr>
<td>17</td>
<td>45</td>
<td>F</td>
<td>Operating room 6/10/58</td>
<td>General anesthesia; breast biopsy</td>
<td>Severe</td>
<td>1 hr.</td>
<td>32°</td>
<td>24</td>
<td>Died 24 hr.</td>
</tr>
<tr>
<td>18</td>
<td>53</td>
<td>M</td>
<td>Operating room 2/7/58</td>
<td>General anesthesia; thoracotomy</td>
<td>Severe</td>
<td>1 hr.</td>
<td>31°</td>
<td>48</td>
<td>Died 3 days</td>
</tr>
<tr>
<td>19</td>
<td>55</td>
<td>M</td>
<td>Operating room 6/16/58</td>
<td>General anesthesia; hernia repair</td>
<td>Severe</td>
<td>3 hr.</td>
<td>30°</td>
<td>8 days</td>
<td>Died 9 days; did not respond</td>
</tr>
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<td>20</td>
<td>57</td>
<td>M</td>
<td>Operating room 9/24/58</td>
<td>General anesthesia; suprapubic prostatectomy</td>
<td>Severe</td>
<td>1 hr.</td>
<td>30°</td>
<td>77</td>
<td>Died 3 days</td>
</tr>
<tr>
<td>21</td>
<td>58</td>
<td>M</td>
<td>Operating room 8/18/58</td>
<td>General anesthesia; pneumonectomy</td>
<td>Severe</td>
<td>6 hr.</td>
<td>31°</td>
<td>84</td>
<td>Died 5 days</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>M</td>
<td>X-ray department 1/22/57</td>
<td>General anesthesia; bronchogram</td>
<td>Severe</td>
<td>2 hr. 40 min.</td>
<td>31°</td>
<td>38</td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>23</td>
<td>6</td>
<td>F</td>
<td>Bronchoscopy 8/12/58</td>
<td>General anesthesia; bronchoscopy</td>
<td>Severe</td>
<td>1 hr.</td>
<td>32°</td>
<td>48</td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>24</td>
<td>9</td>
<td>F</td>
<td>Accident room 8/20/57</td>
<td>Asthmatic attack</td>
<td>Severe</td>
<td>1 hr. 30 min.</td>
<td>30°</td>
<td>34</td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>M</td>
<td>Operating room 4/5/58</td>
<td>General anesthesia; rectal pull-through</td>
<td>Severe</td>
<td>1 hr. 30 min.</td>
<td>32°</td>
<td>72</td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>26</td>
<td>38</td>
<td>M</td>
<td>Accident room 9/28/57</td>
<td>Pericardial tamponade</td>
<td>Severe</td>
<td>1 hr. 50 min.</td>
<td>32°</td>
<td>36</td>
<td>Lived; no residual</td>
</tr>
<tr>
<td>27</td>
<td>39</td>
<td>F</td>
<td>Accident room 11/16/57</td>
<td>Stab wound of chest</td>
<td>Severe</td>
<td>3 hr.</td>
<td>31°</td>
<td>48</td>
<td>Lived; no residual</td>
</tr>
</tbody>
</table>
might be termed true arrest, the following criteria were set up: 1. The arrest was unexpected. Those patients who were critically ill, in whom cardiac arrest might well occur secondary to the stress of surgery and anesthesia, or as a result of disease processes already present, were ruled out. 2. The chest was opened and the heart was noted to be either in asystole or fibrillating. (This is important because even weak cardiac activity can maintain enough circulation to minimize central nervous system damage.)

The table lists the cases and gives the pertinent data concerning the postcardiac-arrest conditions. A gross clinical evaluation of the neurological damage was made and classified as “none,” “moderate,” or “severe.” The category “none” includes the patient who awakens rapidly after an arrest, is well oriented, can answer simple questions, and moves all extremities in an organized fashion. “Moderate” means awake, but irrational, responding some to verbal stimuli. “Severe” indicates coma, convulsions, or spasticity. The first 15 patients listed did not receive hypothermia, while the last 12 were all cooled, as noted.

Those patients who were subjected to hypothermia were cooled as soon as they could be brought to the recovery room, with use of the previously described techniques. A blanket containing a circulating coolant was used. The cooling was aided where necessary by the subcutaneous injection of small doses of meperidine, promethazine, or chlorpromazine. The amounts given were adequate to control shivering but not to depress respiratory or cardiovascular functions. Body temperature was maintained at approximately 31° to 32°C, until there was evidence of improvement. Therapy, otherwise, did not differ from routine postoperative care.

**COMMENT**

Two cases listed in the table in which cardiac resuscitation failed (cases 2 and 3) and six cases in which there was no neurological damage (cases 9, 10, 11, 12, 14 and 15) are excluded from the analysis. There were then 19 patients with neurological injury. Twelve of these received hypothermia, and 7 did not. The clinical courses of these two groups were compared for the value of hypothermia, with the uncooled patients used as a control group.

The effect of hypothermia on survival in cardiac arrest with neurological damage was as follows: Of the 7 patients who were not cooled, only 1 survived; a rate of 14 per cent. By contrast, of the 12 who received hypothermia, 6 survived; a rate of 50 per cent. This marked difference is clinically significant.

The work of Zimmerman and Spencer, referred to earlier, supports this conclusion. Circulation to the brain was occluded for 10 minutes in 26 dogs. Fourteen were subsequently cooled to 31° to 33°C for 24 to 48 hours. Of these, 57 per cent lived. In 12, no hypothermia was used, and only 25 per cent lived. These experiments approximate what occurs in cardiac arrest and justify the clinical use of hypothermia after cardiac arrest.

Among the survivors, there were no cases of residual neurological injury after arrest. One patient (case 27) had cortical blindness which cleared completely after six months. Another (case 13), who was the only patient not undergoing hypothermia who survived, had sensory changes in the lower limbs which were attributed to the effects of the abdominal aortic aneurysm.

Certain points of technique are important for comparing our results with those of others. The shortness of the interval between arrest and cooling is very important, but clinically this is difficult to control. The periods between arrest and cooling in the survivors were from 1 hour to 3 hours. In the cooled nonsurvivors, it was from 1 hour to 6 hours. The depth of hypothermia used was 30° to 32°C. This figure was arbitrarily set because, whereas the beneficial effects on the central nervous system become more salutary the deeper
the hypothermia, the incidence of ventricular fibrillation increases rapidly below 30°C. The duration of the cooled period must be based on clinical judgment. In this series, when improvement was noted, hypothermia was gradually stopped. Among the cooled survivors, the duration of hypothermia ranged from 34 hours to 84 hours; in the non-survivors, it ranged from 3 hours to 8 days.

**SUMMARY AND CONCLUSIONS**

Nineteen patients resuscitated after cardiac arrest with resultant neurological damage were studied as to the effect of hypothermia on the outcome. Seven patients did not receive hypothermia and one lived. Twelve were cooled and 6 lived. The improvement in survival rate from 14 per cent to 50 per cent with use of hypothermia is clinically significant and warrants the use of cooling in all patients who have had cardiac arrest with demonstrable neurological injury.

***

**REFERENCES**


Date: | 4/06/05
Not needed after: |
Account number: |
Budget Year: | 2005
Fund: | CLNOP
Organization: | COM760
Program: | 00111
Sub-Class: | M7020
Project/Grant: |
Project/Grant End Date: |
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Unique Identifier: |
Authors: | Williams GR
Title of Article or Chapt | reprints
Journal or Book Title: | J Okla State Med Assoc
Volume: | 1961 Apr; 54(4):148-152
Issue Number: |
Pages: |
Date of Publication: |

|-------------------------------|
Delivery Information: | send via email
Send by Campus Mail: |
Special Instructions: |
Cost: | $6.35