BLOOD TRANSFUSION IN SEVERE BURNS IN INFANTS AND YOUNG CHILDREN

A Preliminary Report of the Treatment of the Toxic Shock by Blood Transfusion—with or without preceding exsanguination.†

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A review of a hundred consecutive cases of burns and scalds admitted to the wards of the Hospital for Sick Children within the first 24 hours of injury, shows that the greatest number (74%) of severe burns is encountered in children of 4 years and under. An analysis of these cases reveals a startling mortality, not so much from the primary shock, but from the secondary toxic shock, and particularly in those cases of 2 years and under.

Only the cases of burns and scalds severe enough to demand hospital treatment are considered. The slighter cases treated in the out-patient department are not discussed.

The main problems encountered early in severe burns in infants and young children are (a) primary shock, (b) toxic shock.

Primary Shock:—Where the primary shock is so intense that death may occur a few hours after the injury, treatment directed towards relief of the shock is very disappointing and the burn is usually so severe and extensive as to preclude the possibility of recovery either in the immediate or remote future.

Toxic Shock:—In a certain number of cases, the primary shock merges indefinably into the toxic shock, so that no stage of recovery from the former is apparent. This condition renders the success of any form of treatment very doubtful.

There is, however, a type of case in which the primary shock is mild or absent and the burned area though fairly extensive, not deep, but in which fatal result is the rule. Unfortunately, we are all too familiar with the case of the burned child, in which at first the general condition is good, brought in an hour or so after injury showing e.g. a fairly extensive 2nd and 3rd degree burn† of trunk or extremities. On admission, the general condition seems to be better than the extent of the burn might warrant, but in the course of 24 hours or so, the temperature rises, and a convulsion occurs. Cases of this type usually die in 36-60 hours after one or more convulsions, with temperature often as high as 107°. (See Fig. 1.) In older children one may see only cyanosis of the extremities and the signs of circulatory collapse before death.

*A preliminary report before combined sections of Surgery and Pathology Academy of Medicine, Toronto, March 15th, 1921.

†Three other cases between 2-4 years died of bronchopneumonia, infection of burned area, and intestinal haemorrhage, respectively.

†Cases 1-6 reported before combined sections of Surgery and Pathology Academy of Medicine, Toronto, March 15th, 1921.

Fig. 1. Three typical charts of cases of superficial burns dying of toxic shock and not treated by transfusion.
In a recent investigation of the pathology in 10 cases of superficial burns, Weiskotten\(^1\) (see reference) found characteristic lesions in suprarenals, lymphatic tissues and heart muscle "indicating the presence in this class of cases of a more or less specific poison in the circulating blood." These changes commenced a few hours after the injury was sustained and were progressive for not more than three days. In the lymph nodes, at least, retrogression of the lesions began at the end of three days.

It would appear probable then, that there is a toxin produced in the burned tissue and that it is thrown into the blood stream,—that its action diminishes after about three days, either through diminished production, or as a result of the resistance of the body tissues (neutralization or elimination), and it is a significant fact that those cases noted in our statistics as dying of toxic shock practically all succumbed within 60 hours of the receipt of the burn. Clinically, it would seem that the toxin is gradually liberated from the damaged tissue and taken up by the blood, until, in the fatal cases, a cumulative effect is produced on the central nervous system: the temperature rises, and convulsions are precipitated. In the nonfatal cases the absorption of toxin is indicated by a rise in temperature and drowsiness: there are no convulsions, and the toxin is eventually neutralized or eliminated.

It is in the period of toxic shock, before the nervous system has been overwhelmed by the toxin, that treatment directed towards the neutralization or elimination of toxin should be established. Various procedures have been tried, such as the intravenous and subcutaneous administration of saline and of glucose solutions, with the idea of diluting the toxin, and of hastening its elimination, but in the more severe cases, these measures have fallen short of the objective point.

In the hope of overcoming the effects of a circulating toxin, the treatment by blood-transfusion, or the more radical procedure of "exsanguination-transfusion" was carried out in this Hospital. The seven following cases serve as a basis for this report. It will be noted that pneumonia—a not infrequent complication of burns—occurred in two of the cases. In one, which recovered, it followed a chest-wall burn, and in the other it was caused apparently by inhalation of fumes, and resulted fatally.

The technique of "exsanguination-transfusion" is briefly as follows:—

After preparation for the transfusion, blood is withdrawn from the patient until there are beginning signs of blood loss. Where the anterior fontanelle is open, blood may be withdrawn from the longitudinal sinus. In older children, we have used the external jugular, the femoral vein (a cannula being introduced through the proximal part of the saphenous vein) or the radial artery. (It is impossible to obtain any considerable quantity of blood from the superficial veins of the extremities in a child under 5 years of age, particularly if the circulation is sluggish.) The transfusion is then commenced, the donor's blood being introduced by the great saphenous vein over the internal malleolus, while further exsanguination is being carried out carefully. In an infant, it is obvious that only a small amount of blood (up to 120 c. cm.) can be withdrawn before the transfusion must be started, so that after the commencement of the transfusion, the blood withdrawn from the patient must contain an increasingly large percentage of the transfused blood. Notwithstanding this, it is apparent that a considerable amount of the patient's own blood is withdrawn during the procedure, and it would seem to have been in such quantity that enough of the toxin was removed to turn the scales in favor of the patient.

The transfusion is carried out preferably with citrated blood in 100 c. cm. glass syringes, as by this method, a larger supply is more immediately available. It is a wise precaution to have adrenalin at hand for an intravenous injection should any signs of collapse occur during the exsanguination. If, during exsanguination, the margin of safety has been too closely approached and the pulse becomes imperceptible, the transfusion should be begun immediately and \( m \sqrt{y} \) to \( m \sqrt{x} \) of adrenalin 1-1000 given intravenously. This latter is best done by introducing the hypodermic needle into the rubber tube connecting the citrate syringe with the cannula in the vein. The immediate effect of the adrenalin is to produce a sudden blanching of the face, followed by a few dry coughs—the pulse improves almost immediately.

Case 1. G. S., male, age 3 years. Admitted on the afternoon of Dec. 6th, 1919. Forty-five minutes prior to admission, the child upset a
bucket of hot water over himself and remained lying in the hot water for two minutes.

On admission, the general condition was fairly good. There was a 2nd and 3rd degree burn over the back of the neck, both scapular regions, right lumbar region, and right arm down to wrist. T. 98. Pulse 140. Resp. 44. Picric acid dressing applied.

Dec. 7th. 4 a.m. Temp. 101.6
8 a.m. Temp. 104.6. Pulse 160. Patient has had two convulsions and is very toxic. Blood transfusion of 190 c.cm. from father (both in group 4) and in addition 50 c.cm. normal saline.

Dec. 8th. One more convulsion at midnight. General clonic contractions over body. Subcutaneous injection of 200 c.cm. saline and of MgSO4 (8% solution 20 c.cm.) Further progress uneventful apart from development of chicken pox.


Three hours before admission, patient had sustained a severe scald from contact with hot jelly.

On admission, Temp. 99.3. Pulse 100. Resp. 28. General condition good, patient does not appear to be ill. There was a 1st, 2nd and 3rd degree burn of back from the 10th dorsal spine up to neck, and spreading over to the chin on the left side of face. Small area of 2nd degree burn on forehead.

March 11th. 2 p.m. Patient cyanosed and in a convulsion. Muscles in tonic contraction following convulsion with no tendency to relax. 12 c.cm. Mag. Sulph. (8% solution) subcutaneously, and Mag. Sulph. 3 drs. by mouth. Large enema when quiet.

4 p.m. Second convolution. Muscles unrelaxed. Temp. 106.8. An hour later, exsanguination of 250 c.cm. and blood transfusion 300 c.cm. (group 4 to group 4) was carried out. Following this, the condition was somewhat improved and child nursed well.

March 12th. Relaxation still incomplete. 3rd convolution 20 c.cm. of 5% MgSO4 given. Subcutaneously. Colour and breathing improved very shortly. Saline 200 c.cm. subcutaneously.

NOTE.—Extent of burned skin in each case is represented by dotted area on body outline accompanying temperature chart.
March 14th. In last two days there have been five mild clonic convulsions, to relieve which MgSO₄ (5% solution) was given subcutaneously. Child not taking fluids very well. Given more saline subcutaneously.

11 p.m. Exsanguination 120 c.cm.

Blood transfusion 200 c.cm. Following this, colour and general condition improved.

March 15th. Passing urine well. Had six very mild clonic spasms. Receiving high cold colon irrigations. Signs of returning consciousness are apparent as insertion of needles for subcutaneous saline causes pain.

By March 18th. Eighth day of treatment—there was relaxation of muscles, though arms were still a little spastic. Chin and head burns dry. Burned area of back sloughing, but not infected. At this time, child developed a severe lobar pneumonia, for which the usual treatment was carried out, and on April 24th, was discharged from the hospital in excellent condition.

Case 3. N. H. No. 21966 Male. Age 2 years. Admitted Aug. 10th, 1920, 7 p.m. Two and a half hours prior to admission child sustained severe burns through its clothes catching fire.

On admission, T. 100. P. 150. R. 40. Patient a poorly-developed rachitic infant, is restless and crying. Some convulsive movement of limbs, respirations rather labored and rapid, mucus in throat. Burns of 1st, 2nd, and 3rd degree—face, both arms and thighs, burn of 4th, 5th degree of right hand.

11 p.m. Exsanguination 100 c.cm.

Transfusion 180 c.cm. (donor and recipient in same group) Saline 200 c.cm. (given very slowly) (Intravenously.)

Aug. 12th. At 5 p.m. Temp. 104. Condition becoming worse.
Exsanguination 20 c.cm. after which needle became dislodged from longitudinal sinus.
Transfusion. 200 c.cm. Saline 100 c.cm. (given slowly) (Intravenously)
By 10 p.m. patient’s condition improved. Aug. 13th. No convulsive twitchings, taking fluids well, respiration rapid, but patient conscious.
Aug. 14th. Fairly well all day, till 6 p.m., when condition became worse.
Exsanguination 100 c.cm.
Transfusion 160 c.cm.
Saline 80 c.cm. intravenously.

Autopsy showed intense purulent bronchopneumonia, with right base almost completely consolidated.

Case 4. H.Y. Age 19 months.
Admitted in the morning of Dec. 10th, 1920. Two days prior to admission spilled hot coffee over the front of the chest. Patient said to be in good condition till this morning when she had two convulsions, one at 6 and one at 7.30 a.m.

On admission, Temp. 105. Pulse 160. Patient drowsy, toxic, and semi-delirious with convulsive twitchings, appears to be acutely ill. Area of burn over chest and base of neck about 40 square inches. Burn is of 1st, 2nd, and 3rd degrees.
On morning of admission, blood transfusion of 200 c.cm. was done (4% citrate) and 50 c.cm. saline were given into a vein. Following transfusion, condition improved though slight twitching of arms was present. 20 c.cm. Mag. Sulph. Sol. (8%) given subcutaneously.

Dec. 11th. General condition much improved, T. 100. Patient has lost the drowsy toxic appearance and is able to recognize her mother.


Feb. 11th, 1921. Burn well healed, and patient in excellent condition.

Severe scald over whole anterior surface of chest and abdomen.

Patient in some degree of shock on admission.

5 p.m. Recovered from primary shock.

7 p.m. Circulatory collapse.

8.30 p.m. Convulsive twitchings of arms and legs.

Transfusion 300 c.cm. Blood.

25 c.cm. Mg. Sol. (8%) subcutaneously.

This was followed by definite improvement.

Dec. 18th, 1920. 5 a.m. Convulsive twitchings 25 c.cm. Mg. SO4 (8%).

10 a.m. Condition poor but no convulsions.

1 p.m. Severe convulsion.

Exsanguination 260 c.cm.

Transfusion 300 c.cm.

Following this, patient's condition was very much improved, and he became quiet and rational.

4 p.m. Convulsive twitchings 25 c.cm. Mg. SO4 (8%).

8 p.m. Died following convulsion which lasted one hour. Necropsy refused.

Case 6. P.K. Age 1½ years.

Admitted March 1st, 1921 and still in hospital.

Scald of legs and scrotum of 2 hours duration. Admitted in good general condition. No shock present.

March 2nd. 4 a.m. Patient drowsy.

11.20 a.m. Severe general convulsion, lasting 5 minutes, face and hands cyanosed. (Donor being searched for, father's blood incompatible.)

12 noon. Slight convulsion.

2 p.m. Exsanguination 200 c.cm.

Transfusion 400 c.cm. (foreign donor).

3 p.m. Convulsion, immediately after return
from operating room. Lumbar puncture done; 45 c.cm. of clear fluid under considerable pressure. 3 c.cm. of Mg. SO (8%) introduced intraspinally.

March 11th. Steady improvement.

March 14th. Nasopharyngitis with otitis media. Burns in good condition and healing.

Case 7. R.B., Male. Age 2½ years.

Admitted to Hospital March 27th, 1921.

Six days prior to admission, child had fallen backwards into a tub of scalding water. He had been treated at home with various local applications for a 2nd and 3rd degree burn, extending over the back from the lower angles of the scapula to the upper portion of the thighs, and forward to the mid auxiliary line on each side. Frequent doses of paregoric had been given for the relief of pain. He was desperately ill on admission to hospital, and the extent and severity of the burn were such that the prognosis seemed absolutely hopeless. On admission, the child was exceedingly restless and toxic. Morphia was given to control pain and borated vaseline on moist boric acid lint was applied to the burns. In the hope of controlling the toxaemia blood transfusion of 360 c.cm. was done immediately.

Following transfusion, he showed moderate improvement, but the temperature remained high. Cold colon irrigations were given. These were of temporary benefit in lowering the temperature, but by March 1st the condition had become worse. The manifest circulatory collapse was treated by the giving of adrenalin m Y and camphor gr. 2. There was increasing restlessness, and at noon, a severe convulsion occurred. Exsanguination (260 c.cm) and transfusion (400 c.cm.) was carried out. Following this, general condition improved somewhat, but there was intermittent twitching of arms and legs. Mag. Sulph. Solution (8%) was given subcutaneously at intervals in 20 c.cm. doses for the next four days to control the spasms.

By March 3rd, the general condition was very definitely improved, and the temperature somewhat lower. However, the improvement was not lasting, and by March 6th the condition was again very poor. Patient was taking very little fluid and passing very small quantities of urine. He was restless, was at times delirious, and slept for only short periods. This state continued till March 9th, at which date it seemed that the outlook was quite hopeless. The circulation was waning perceptibly, the face and hands were mottled and bluish, and the radial pulse was at times imperceptible. The toxaemia, was obviously increasing. As a last resort, blood transfusion was carried out (300 c.cm.).

The following day, the temperature began to fall and with the exception of an occasional rise, became steadily lower. The general condition improved daily, and by March 14th the child was taking solid food. Further progress has been uneventful; at the time of writing, April 29th, there are several large granulating areas over both loins. At no time during his illness did the urine show albumin or casts. From the extent of the burn in this case, it is difficult to see how he could have lived beyond the first four days.

Admittedly, this is a very small number of cases upon which to base conclusions and the method is yet on trial, but the results from other forms of treatment in this type of case have been so uniformly discouraging that a radical deviation from former lines of procedure was warranted. We have endeavoured to determine what sign or symptom is an indication for this therapy, but such measures as examinations of the blood and urine has shown nothing suffi-
ciently definite, so far, to point the way, and we are forced to rely upon the clinical points like rising temperatures and general evidences of increasing toxemia. The occurrence of a convulsion is a certain indication, but, unfortunately, a late one, and it would be safer to institute treatment before the toxin has been so fixed as to cause convulsion. Our experience has been that in a case under two years of age, in which the burns have been severe enough to cause a convulsion, it is rare to see recovery follow any other method of treatment.

The animal experimental work and blood chemistry in connection with this subject are being carried out in conjunction with Dr. Gladys Boyd, in the Research* Laboratories of the Department of Pediatrics. The results will be reported in a subsequent paper.

Out of seven cases of severe toxic shock from superficial burns, showing symptoms which we are accustomed to consider as those almost invariably present in the fatal cases, five have recovered completely. This is considered sufficient justification for the appearance of an advance clinical report in the hope that other workers in the field might gain some advantage from its perusal.

* Dupuytren's classification.

TABLES RELATIVE TO THE TRANSFUSION OF BLOOD

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Those who practise the transfusion of blood endeavour to prevent undesirable sequelae by carrying out preliminary tests to ascertain the group to which the blood of the donor and that of the recipient belong. Four groups are commonly recognized, and are designated 1, 2, 3 and 4.

The agglutination reactions of these groups are expressed in the following table:

<table>
<thead>
<tr>
<th>TABLE I.</th>
<th>Erythrocytes</th>
</tr>
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<tbody>
<tr>
<td>Group 2</td>
<td>Group 3</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
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<tr>
<td>2</td>
<td>+</td>
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<tr>
<td>3</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
</tr>
</tbody>
</table>

+ = agglutination. 0 = no agglutination.

The test for selecting a donor is frequently made by testing suspensions of the erythrocytes of the donor and of those of the recipient against standard sera of groups 2 and 3. The following table, which is obviously derived from Table I., shows how the group of each unknown blood is ascertained.

<table>
<thead>
<tr>
<th>TABLE II.</th>
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<tbody>
<tr>
<td>Unknown</td>
</tr>
<tr>
<td>erythrocytes</td>
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<tr>
<td>x</td>
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<td>x</td>
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</tbody>
</table>

+ = agglutination. 0 = no agglutination.

Concerning the explanation of these well-known facts, much has been written. Von Dungern and Hirschfeld offer what is probably the best explanation, of which the following summary presents the essentials.

In the human species there are four varieties of erythrocytes:

1. Erythrocytes A, which possess an agglutinable property termed A.

2. Erythrocytes B, which possess an agglutinable property termed B.

3. Erythrocytes AB, each of which possesses both agglutinable properties A and B.

4. Erythrocytes O, which possess neither agglutinable property, neither A nor B.