PART 7

Chairman: H Dutz
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Experiences in Paediatric Haemodialysis

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Between 1918 and 1920 American and German paediatricians used the resorptive qualities of the peritoneum for therapeutic substitution of fluids in newborns and infants. Although towards the end of the forties American and Dutch nephrologists had carried out treatment by haemo- and peritoneal dialysis in children for the first time, these therapeutic methods did not find general acceptance in paediatrics for several years.

In the last few years, however, the number of reports of dialysis treatment in children increased markedly: not only in the management of acute renal failure and exogenous intoxications but also in terminal renal insufficiency in patients of the paediatric age group (Fine et al, 1969, 1970; Shaldon et al, 1969; Broyer et al, 1970; Cameron et al, 1970; Gusmano et al, 1970; Potter et al, 1970; Boulton Jones et al, 1971; Schüler et al, 1971; Brunner et al, 1972).

Since 1967 the Department of Urology in Heidelberg has been running its own dialysis unit providing haemodialysis in connection with renal transplantation and for acute renal failure in surgical patients.

In 1969 we started performing haemodialysis in children. Between December 8th, 1967 and May 31st, 1972 we carried out a total of 3482 haemodialyses in 182 patients with ages ranging from 9 weeks to 82 years. 2692 (ie 77.3%) of the total number of haemodialyses were carried out in 45 children with ages between 9 weeks and 16 years.

Figure 1 gives the distribution of age and the mortality rate in these 45 haemodialysed children with an average age of 8.2 years, grouped according to the following indications: exogenous intoxication, acute renal failure and chronic renal failure.

Eleven children (ie 24.4%) up to the age of 7 years were sent to us for dialysis treatment of acute renal failure and exogenous intoxication. The majority of the older children (ie 62.2%), however, were intermittently haemodialysed because of chronic renal failure ($C_{CR} < 3ml/min1.73 m^2$).
DISTRIBUTION OF AGE AND PERCENTAGE OF MORTALITY IN 45 CHILDREN

I. EXOGENOUS INTOXICATION  
\( n = 8 \)  
\[\text{Average Age (Range)}\]  
1. 4 2/12 (1 11/12 - 12 2/12)  
2. 8 3/12 (2 1/2 - 15 7/12)  
3. 11 1/4 (7 10/12 - 10 2/12)  
\( \% \text{ of Mortality} \)  
1. 0.0 \%  
2. 63.6 \%  
3. 37.5 \%  

II. ACUTE RENAL FAILURE  
\( n = 11 \)  
3. 11 9/12 (7 11/12 - 12 5/12)  
\( \% \text{ of Mortality} \)  
4. 10.0 \%  

III. CHRONIC RENAL FAILURE  
\( n = 28 \)  
10. 8 2/12 (2 11/12 - 14 6/12)  
\( \% \text{ of Mortality} \)  
11. 26.6 \%  

TOTAL NUMBER  
\( n = 45 \)  

Figure 1. Distribution of age and percentage of mortality in three different treatment groups

Intoxications

Successful haemodialysis was carried out in five children after exogenous intoxications. Four of these children – with ages ranging from 1.7 to 4.7 years (average 3.7 years) had taken twice the lethal dose of a medicament (imipramine in two cases, isoniazid in one case) or a detergent (marble polish consisting of trichlorethylene, perchlorethylene and wax). The fifth case, a 12 year old boy, had swallowed 60 tablets of a sedative (Sediomed). In our opinion the early initiation of haemodialysis – 2 to 6 hours after the intake of the toxic agent in the presence of severe clinical symptoms – contributed very much to the encouraging results in this group which compare favourably with the overall mortality of around 15% reported in the literature.

Acute renal failure

In contrast to the satisfying results in the treatment of exogenous intoxications the mortality rate in patients with acute renal failure was relatively high (Figure 1 and Table I).

Only 4 of the 11 children survived (ie 36.3%). Before the first haemodialysis in our unit blood urea ranged from 122 to 444 mg/100 ml with an average of 249.5 mg/100 ml. The average creatinine was 6.04 mg/100 ml
with a range from 2.6 to 12.4 mg/100 ml. When haemodialysis was started in these patients all of them had been oligo-anuric for several days.

Table I. Causes of acute renal failure and results of haemodialysis in 11 children

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Cause of renal failure</th>
<th>Dialysis No</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. KH</td>
<td>9 2/12</td>
<td>m</td>
<td>Septicaemia (E. coli)</td>
<td>2</td>
<td>died</td>
</tr>
<tr>
<td>2. AM</td>
<td>211/12</td>
<td>m</td>
<td>Haemolysis after Bialock-operation</td>
<td>1</td>
<td>died</td>
</tr>
<tr>
<td>3. MM</td>
<td>12</td>
<td>m</td>
<td>Haemolytic-uraemic syndrome</td>
<td>13</td>
<td>died</td>
</tr>
<tr>
<td>4. UL</td>
<td>1 8/12</td>
<td>f</td>
<td>Septicaemia (Pneumococcus)</td>
<td>5</td>
<td>died</td>
</tr>
<tr>
<td>5. TO</td>
<td>1 2/12</td>
<td>m</td>
<td>Hypotension after rectosigmoid-resection (Hirschsprung’s Disease)</td>
<td>7</td>
<td>recovered</td>
</tr>
<tr>
<td>6. TS</td>
<td>1 5/12</td>
<td>f</td>
<td>Haemolytic-uraemic syndrome</td>
<td>4</td>
<td>recovered</td>
</tr>
<tr>
<td>7. TW</td>
<td>2/12</td>
<td>m</td>
<td>Toxaemia, renal vein thrombosis</td>
<td>3</td>
<td>died</td>
</tr>
<tr>
<td>8. GS</td>
<td>15 7/12</td>
<td>m</td>
<td>Shock, multiple fractures, tetraplegia</td>
<td>12</td>
<td>recovered</td>
</tr>
<tr>
<td>9. KG</td>
<td>13 5/12</td>
<td>f</td>
<td>Hypotension after correction of Fallot IV</td>
<td>10</td>
<td>died</td>
</tr>
<tr>
<td>10. TR</td>
<td>10 5/12</td>
<td>m</td>
<td>Hypotension after correction of Fallot IV</td>
<td>3</td>
<td>died</td>
</tr>
<tr>
<td>11. MK</td>
<td>1 1/12</td>
<td>m</td>
<td>Gastroenteritis</td>
<td>6</td>
<td>recovered</td>
</tr>
</tbody>
</table>

In 45% of all dialysed cases acute renal failure developed after surgery or accidents and in 36% because of toxic renal failure. Patient No 2 died of acute cardiac arrest during the first dialysis treatment 115 minutes after the dialysis had been started. The six other cases of acute renal failure lost during treatment were complicated by severe cardiac, respiratory or cerebral insufficiency. Before admission to our unit cases No 1 and 3 had been treated by peritoneal dialysis with rapid deterioration of their clinical condition.

Chronic renal failure

The 3rd group – patients with chronic renal failure – has been divided into two sub-groups:

(a) children transferred to us from other centres to undergo surgery, and

(b) children in whom the chronic dialysis programme was started in our unit (Figures 1 and 2).

The eight children transferred from other centres were sent to us for surgical intervention ie mostly for bilateral nephrectomy in cases of otherwise intractable hypertension, massive gastrointestinal bleeding or cerebral haemorrhage. One died of sudden cardiac arrest a week after initial recovery from bilateral nephrectomy, the autopsy revealed hypertensive cardiomyopathy. A nine-year-old girl who had already been treated with 35 peritoneal dialyses at a different clinic was transferred to us with an acute hypertensive cerebral haemorrhage and died after two haemodialyses carried out at our unit. An 8-year-old girl died of continuous intractable bleeding from ulcerative oesophagogastrroduodenitis after 24 subsequent haemodialyses because surgical treatment was thought to be impossible. The 20 children
in our own programme cover a total of 216 dialysis-months. The causes of chronic renal failure in these 20 patients of our own programme is shown in Figure 2.

Two children received a cadaver transplant and have been living with functioning grafts for a total of 52 months. Unfortunately equally well matching grafts were not available for the other children, so our goal of improving rehabilitation by transplantation comes up to only 3% of our Urology Transplant Programme consisting of a total of 90 cases so far.

Nineteen of these 20 children (ie 95%) had to be dialysed because of acute-on-chronic renal failure. Only two of these patients died although all of them had been moribund at their admission before the beginning of the first dialysis and would have died a few days or weeks later of uraemia.

One of them was anephric after losing a solitary kidney by a traumatic lesion. During the second haemodialysis he died of an air embolism. The other child lost had cystinosis and died of unexplained cardiac arrest during the 10th dialysis.

At admission almost all the children showed massive fluid retention with pulmonary oedema, marked pericarditis and cerebral oedema which had lead to a corresponding clinical symptomatology but which was usually reversible after a few haemodialyses with ultrafiltration of up to 8 kg within the first 48 hours.
In six of 20 children (ie 20%) peritoneal dialysis performed in other hospitals before admission to us had led to considerable clinical deterioration with massive fluid overload. In these children initial blood urea was 346.2 ± 131.5 mg/100 ml, creatinine 18.7 ± 6.86 mg/100 ml. After only a few weeks 16 children (ie 80%) had been rehabilitated to such an extent that they could be dialysed as outpatients. In the interval between dialysis treatments they live as normal children and are able to go to school.

At the moment 7 children are dialysed on an ambulatory basis 4 - 7 hours 3 to 6 times per week. Four children living too far off can leave the hospital for the weekends only. Five children - Case No 6, 8, 9, 10, 12 (Figure 2) - were transferred to haemodialysis centres near their homes where they have been dialysed for a total of 13 patient-months.

On the whole children dialysed on an ambulatory basis are very co-operative and in contrast to many grown-ups extremely disciplined. Apart from well-known problems such as occasional hypertensive crises, anaemia and fluid overload above average as well as a tendency to take medicaments irregularly we did not observe further difficulties.

To demonstrate one of the above mentioned problems the X-ray pictures of a 14-year-old boy are shown who had been in our chronic dialysis programme for ten months. During 48 hours between two dialyses, however, he accumulated 5 kg of fluid as shown, in the chest X-rays taken before the beginning of dialysis (Figure 3a) and eight hours later after a loss of 5.3 kg (Figure 3b). A few weeks later the boy had become extremely disciplined and co-operative again. Since then no further problems have been observed in his condition.

Neither at home nor at our unit are the children subject to any hard dietary measures beside a slight sodium chloride and potassium restriction, which, however, is generously dealt with. The minimum protein intake per day should be 1.5 to 2.5 g per kg of body weight. Additional doses of polyvitamin and iron medicaments are obligatory. All children receive a routine dose of 1000 - 1500 mg of calcium per day. If the X-ray examination shows severe symptoms of uraemic osteopathy Vitamin D in a dose of 10 000 - 40 000 units/per day is administered.

At the beginning of dialysis treatment X-rays showed uraemic osteopathy in 17 children (ie 85%). According to X-ray examination an improvement was found in three out of nine patients dialysed for more than one year, whereas the condition of one child remained unchanged. One other child showed an improvement in the metaphysis area and a worsening in the phalanges area. In four children, however, X-ray revealed increasing osteopathy.

On the basis of our experiences up to now we should like to stress the following important points about the infantile and adolescent skeleton during
Figure 3. Chest X-ray of a 15 year old boy
(a) after massive fluid ingestion before haemodialysis showing fluid lung and cardiomegaly
(b) appearance after 7 hours of haemodialysis with a reduction of body-weight of 5.5 kg
intermittent haemodialysis:

(1) Relatively fast changes in the metaphysis within a few weeks or months (high turn-over),
(2) High calcium dependent density in some epiphyses of the digital bones,
(3) No calcification of the intervertebral disks,
(4) No calcinosis of vessels and soft tissues.

Maturation of the ossification centres proceeded during long-term dialysis. Not even during puberty did the older children show any pathological findings. Before the beginning of dialysis treatment almost all children had an arrest of growth. During treatment, however, an increasing growth was found. In a now 12-year-old girl – case No 3 – this came up to 15 cm during 33 months of dialysis after the child had shown an arrest of growth during the last four years before the beginning of the dialysis treatment. This girl had undergone bilateral nephrectomy 25 months before, and during the last sixteen months has been dialysed as an out-patient, apart from several days in hospital.

We should like to comment shortly on the rate of transfusion as a further clinical problem. Reducing the rate of transfusion is important to avoid transfusion-bound hepatitis and circulating antibodies with regard to future transplantation.

The individual rate of transfusion during 216 dialysis months is evident in Figure 2. The crosses indicate transfusions given during surgery, whereas the points stand for transfusions given when the haematocrit fell below 12%. Reading Figure 2 from the left to the right a decreasing number of transfusions becomes evident. Up to the time indicated by arrow 1 coll kidneys were exclusively used. In the time following we only used Alwall-Gambro dialysers – 3, 6 and 11 layers. As the blood loss was relatively high during haemodialysis with the Ab Gambro System we developed a meticulous reperfusion technique from the time indicated by arrow 2. From that time on the number of transfusions decreased as evident in the right part of Figure 2. Three children did not have any transfusions in the last 42 dialysis months – Case No 5, 6, 7, Figure 2.

Although the rate of transfusion was relatively high and several adults admitted to us for renal transplantation showed contamination with Hepatitis Associated Antigen only two of the children chronically dialysed in our unit were affected with hepatitis.

Among the surgical problems coming up during haemodialysis in children we specially want to refer to the difficulty of vascular access.

Figure 4 gives the different types of vascular access we have used in 45 children. External shunts are marked 'S' and subcutaneous fistulae 'F'.

Puncture of femoral vessels or the insertion of Shaldon-like catheters have only been used in exogenous intoxications in two children, both
Figure 4. Vascular access in 45 children of different ages

approximately one year old. In acute renal failure we used peripheral vessels in the forearm. With that method we were successful in inserting Scribner-shunts in the radial artery and a neighbouring vein in 4 patients down to the age of one year. When this seemed to be time-consuming or otherwise impossible, brachial shunts with a special technique were used connecting the brachial artery with the basilic vein (Schüller et al, 1971). During the initial period of chronic intermittent haemodialysis Scribner-shunts are used, installed at the forearm or lower leg.

Using the radial artery the average time of the Scribner-shunts functioning was 8 months with a maximal time of 28 months in a now 12-year-old girl – Case No 3.

Shunt-infections and clotting accounted for most of the complications of the Scribner-shunts. Infections could be successfully controlled in 4 cases, however, infections finally lead to displacement or removal of the shunts. During 160 shunt-months clotting was the major disadvantage of the Scribner-shunt occurring about 80 times in 14 children, the clotting rate being
especially high in 4 children.

In case of clotting our therapeutic regime is local flushing with heparinised saline, local or systemic application of fibrinolytic agents, or direct removal of thrombi or valve-like endothelial lesions using a Seldinger guide wire.

AV-fistulae in the forearm or upper arm were created whenever terminal uremic children were closely supervised and could thus be prepared in time for haemodialysis.

Up to now we have had 17 cases of AV-fistulae; 13 of which were created in our department and 4 in other centres prior to admission to our hospital. Fourteen of these fistulae are still functioning well with a duration of 154 months.

We think that there is no question about the indication for haemodialysis in children with intoxications, acute and acute-on-chronic renal failure. It still seems unclear to us, however, what will be the future physical, psychological and technical problems of long-term haemodialysis on the part of the children and their families.

Although contrary to our earlier expectations the reported results of regular haemodialysis treatment in children might favour a broad indication for this treatment, we are certain that only on the basis of the experiences of all centres performing haemodialysis in children can a definite indication for long-term paediatric haemodialysis be achieved.

ACKNOWLEDGMENT

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REFERENCES


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OPEN DISCUSSION

B NIELSEN (Copenhagen): I would like to ask you if you have any comment on the growth rate of your patients on regular dialysis because you carry them through for extended periods.

SCHÜLER: The growth rate in our series was apparently improved by dialysis, especially when we switched over to a scheme of dialysing more than three times a week. We now have a group of children who are on dialysis six times a week and we are gaining the impression that this regular treatment is beneficial for the growth rate. We now have experience with a total of, I think, six who show regular growth and have now successfully entered puberty. All show signs of pubertal growth, and the girls have normal menstrual cycles.