Twenty five years of haemodialysis.
A tribute to the pioneer work of the Belfast Renal Unit

David N S Kerr

The first artificial kidney to be used in the British Isles was one of Kolff’s original four which he donated to Hammersmith Hospital soon after the end of World War 2. It was used for a while in the late 1940’s but was then relegated to the basement when enthusiasm for the conservative treatment of acute renal failure was at its height. To my chagrin it is now displayed in a museum in the USA. Professor Darmady built a similar machine in 1946 and used it for a few years in Wessex. However, haemodialysis only became a routine treatment for acute renal failure when Frank Parsons set up the Renal Unit in Leeds and imported an improved version of Kolff’s rotating drum kidney. A similar machine was installed by Professor Shackman at Hammersmith Hospital a few months later and the RAF set up a unit at Halton under Sir Ralph Jackson. These three pioneer centres demonstrated to Britain what earlier trail-blazers like Swann and Merrill had shown America — that the artificial kidney was life saving in acute renal failure. From 1958 regional centres began to spring up all over Great Britain and Ireland starting with Dublin, Glasgow, Newcastle and Belfast.

The Belfast Unit was born in 1959, the year in which I made my own first acquaintance with the haemodialysis. I have described elsewhere the sweat and tears, the hilarity and comradeship of those early years when the artificial kidney was a monster to tame, when its design was so crude that a manoeuvre as simple as inflating a cuff around a coil could almost double its efficiency and when most of the equipment was improvised on DIY principles. Budding nephrologists were interviewed in their dungarees, spanner in hand, and they doubled up as nurse, technician, porter, engineer, dietitian and hospital cleaner. It was training on the job which left a permanent mark on Mollie McGowen and her generation.

A few months after the Belfast Unit was founded, an event took place which was to divert our attention from acute renal failure and reshape the history of renal medicine; regular haemodialysis for chronic renal failure started and has dominated the life of Belfast, and all other renal units, ever since.

THE BIRTH OF REGULAR HAEMODIALYSIS

In 1957 I met Dr Belding Scribner who had just arrived at Hammersmith Hospital for a sabbatical with Dr Malcolm Milne. It was no biblical sabbatical. He turned his inventive mind to writing teaching programmes in fluid and electrolyte balance; to devising bedside biochemical techniques 20 years ahead of the state of the art; to tinkering in the workshop with designs for indwelling cannulas; and to formulating the ideas which came to fruition on his return to Seattle. There,

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frustrated by his inability to keep an indwelling cannula patent, he had a chance
collection with a colleague who recommended the newly introduced material
PTFE (Teflon). Two essential ingredients made the rest of the story possible. The
first was his partnership with Wayne Quinton whose technical skill translated
Scribner’s ideas into practical hardware. The second was his unshakable faith that
if he could overcome the technical difficulties he could prolong life in chronic
renal failure by long-term haemodialysis. Scarcely another soul in the world
shared his faith, but in 12 months he confounded his critics. In May 1985 the
Royal Postgraduate Medical School paid its tribute to one of its most famous
alumni by conferring on him the Fellowship of the School 25 years after the first
successful treatment of chronic renal failure.

However, success was not instantaneous. In the early 1960’s the trials of
haemodialysis for acute renal failure were soon eclipsed by those of dialysis for
chronic renal failure. Our faltering start in Newcastle was typical of the time.
Excited by Scribner’s first reports5,6 we began to look on every young patient with
chronic renal failure as a potential start to the Newcastle programme, but we had
no suitable equipment, no space, no staff and no money to get started. One
young man dying of renal failure, with a young wife and two small children to
support, gave as his occupation “fruit machine operator”. We wondered whether
the night club owner who employed him could raise the cost of importing a
Sweden Freezer machine and Kill dialyser from America. He was delighted to do
so and set up charity concerts in all his night clubs, to which entertainers willingly
gave their services free. In faith we ordered the machine and waited impatiently
for the slow boat from Seattle. It arrived too late for our young man and we never
saw a penny of the night club money. It was the only time we were let down, for
from then on we forgot the rich and appealed to the poor. The ordinary folk of
Northern England gave with unbelievable generosity, rivalled only by that of their
opposite numbers in Ulster where Mrs Josie Kerr and her colleagues have done
so much to support the Belfast Unit.

We were left with a big debt and an idle machine, but the latter was soon
remedied. A Newcastle trained nurse with renal failure, who lived with her
husband in Essex, was given a death sentence and came home to her parents for
terminal care. We offered her the dubious privilege of being our first guinea pig
and she jumped at it. Like most of the patients of that era she arrived almost in
uraemic coma and went through three weeks of psychosis and confusion before
pulling through to restored health. After 6 months she was transferred to the care
of Dr Stanley Shaldon at the Royal Free Hospital and became Britain’s first home
dialysis patient. She died after 7 years of bravery in the face of innumerable
challenges and vicissitudes, one of the many whose courage kept us going when
at times the defects in our treatment seemed so great that it was scarcely worth-
while carrying on.

Today the patient of 35-54 years starting home haemodialysis has a better that
80% chance of surviving 5 years, and the young adult who receives a cadaver
graft from haemodialysis or CAPD has a 90% chance of surviving 3 years.7 This
is still well below the life expectation of the rest of the population, but it is
immensely better than the results recorded in the first two European Registry
annual reports8,9 when 40% of patients starting dialysis died in the first six
months, 10% of deaths were due to cachexia, 10% of living patients had
symptomatic peripheral neuropathy and the average patients received between
2 and 3 litres of blood per month. In this lecture I have tried to pick out the
advances in haemodialysis which I believe have contributed most to this transformation of the results in the last 2 decades.

ADVANCES IN HAEMODIALYSIS 1: ACCESS TO THE BLOOD STREAM.

The original Quinton-Scribner all-Teflon shunt was soon displaced by a much more convenient combination of a Teflon tip and a flexible silicon-elastomer (Silastic) tube. The original design had a U-bend under the skin to prevent the transmission of movement to the tip; this design is still in use at Hammersmith today, but in Newcastle we rapidly changed over to a straight tube which was much easier to declot with the help of a nylon tube. We did not routinely use the Ramirez winged modification, designed to improve subcutaneous stability, because it increased the difficulty of removing failed shunts. I am not aware of any controlled study comparing the longevity of these different designs but our clinical impression was that there was little to choose between them, so we chose the simplest and cheapest.

For a few patients the shunt was an ideal method of access. My longest lived leg shunt ran for 7 years with one revision of the venous tip and with the arterial site unchanged. For that patient, who did not engage in any rough work and was adept at bathing with one foot out of the water, it was hard to imagine a more convenient system. But for every one like that there were a dozen who suffered for their shunts and dragged down the average survival shown in Table I. This table is based on a survey carried out by a Newcastle medical student engaged in a student research project at the time when shunts were being replaced by fistulas. She recorded the life history of all shunts and fistulas carried out on the 100 or so patients then on dialysis in Newcastle. Since the majority of fistulas were still functioning and the majority of shunts had failed, a direct life-table analysis of the two methods was not very meaningful.

Table 1

The fate of arteriovenous Silastic-Teflon shunts of patients surveyed in Newcastle-upon-Tyne, 1974

| 191 shunts inserted | 1 patient died with functioning shunt |
|---------------------|--------------------------------------|
| 140 shunts failed    | 45 shunts removed post-dialysis       |
|                     | 5 shunts still functioning            |
| Average life of site| 11.4 months                          |
| Average gap between surgical revisions*| 4.1 months                          |

*Any procedure beyond simple declotting or thrombolysis.

However, Table I gives a sufficient glimpse of what the shunt did to the lives of dialysis patients. With a mean life for each shunt site of about 1 year and with an average of 3 reasonable sites on each upper limb and one on each lower limb, the threat of “running out of access” was real enough to give patients a constant source of anxiety even though, in practice, only one patient in Newcastle died primarily from this cause. Charting the remaining shunt sites, noting whether the arterial walls felt healthy and whether there were murmurs over the proximal
vessels, became part of the routine 6 monthly assessment of dialysis patients. However, the real problem with shunts was the effort required to keep them going. The commonest cause of failure was stenosis of the vein, less commonly of the artery, just proximal to the Teflon tip. At the site of the stenosis, thrombus formed readily, occluding the shunt. Patients were taught to monitor the shunt frequently, examining the colour of the blood in the Silastic tube, or listening over the vein with their stethoscope. Each time a shunt clotted they made a trip by car or ambulance, some of them travelling 100 miles or more to reach the renal unit; sat through an unpleasant declotting session and went home sometimes to find that the shunt had clotted again the same night.

Their great salvation was the Cimino-Brescia fistula. Table II shows the results obtained in 1974 in Newcastle. They were not the best in the world, but they were probably the sort of results that were obtained in most British units where one consultant and his rotating registrars shared the task of creating the fistulas.

**Table II**

(a) *The fate of arteriovenous (Cimino-Brescia) fistulas surveyed in Newcastle-upon-Tyne, December 1974*

| Fistula site                           | Total | Failed by 48 hours |
|----------------------------------------|-------|--------------------|
| Radio-cephalic                         | 139   | 23 (16%)           |
| All other sites                        | 52    | 12 (23%)           |
| Anatomical snuffbox                    | 13    |                    |
| Antecubital fossa                      | 19    |                    |
| Saphenous loops                        | 13    |                    |
| Miscellaneous                          | 7     |                    |

(b) *Effect of fistula site on early failure*

| Fistula site         | Total | Failed by 48 hours |
|----------------------|-------|--------------------|
| Radio-cephalic       | 139   | 23 (16%)           |
| All other sites      | 52    | 12 (23%)           |
| Anatomical snuffbox  | 13    |                    |
| Antecubital fossa    | 19    |                    |
| Saphenous loops      | 13    |                    |
| Miscellaneous        | 7     |                    |

(c) *Causes of late fistula failure*

| Cause                               | Count |
|-------------------------------------|-------|
| Thrombosis                          | 8     |
| Sudden, spontaneous                 | 5     |
| Post-dialysis                       | 2     |
| From compression                    | 1     |
| Gradual stenosis                    | 7     |
| Infection and aneurysm              | 1     |
| Ligation for heart failure          | 1     |
| Haemorrhage at each dialysis        | 1     |
| **Total**                           | **18**|

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For most patients the radial fistula was the single answer to blood access; it lasted them until their successful transplant and often remained patent to await their return to dialysis if the transplant failed. The radial fistula's long life expectation and relative freedom from complications gives it a long lead over the many alternatives which are rightly used as secondary measures when the fistula fails or cannot be created: proximal fistulas, saphenous loops or straight grafts; expanded PTFE (Gortex) grafts; bovine heterografts; Thomas appliqué shunts etc. These second and third line measures are required because patients live longer. In 1979 the EDTA-ERA Registry had records of more than 3000 European patients who had survived more than 10 years on renal replacement therapy; about a third had never been transplanted.10 Today there must be several thousand patients in their second decade of haemodialysis; one centre has a 15 year survival of 65%.11 However, the relatively short survival and the complication rate of all alternatives to the radial fistula justify Dr Lumley’s description of vascular access as the Achilles heel of haemodialysis, even in 1984.12 The difference is that it is now the Achilles heel for a few patients when, in the era of the shunt, nearly every patient fervently wished he had been completely immersed in the Styx.

I therefore view as the most hopeful recent development in blood access the increased attention to preserving the radial fistula. Immediate exploration of fistulas that fail early can often save one fistula site. Late failure can be anticipated, the fistula studied by ultrasound or digital subtraction angiography and stenosis treated by balloon angioplasty or surgical revision. However, I believe that the biggest contribution in Britain could come from more use of skilled surgeons for the initial fistula operation. This is not a job for the casual surgeon. Most nephrologists take the view that registrars should not learn to do renal biopsies unless they plan to become nephrologists, when they should be thoroughly trained. If the same approach were adopted in vascular access surgery, many of our problems would fade away.

However, there are a few patients whose tiny veins after prolonged steroid therapy and careless misuse during their earlier treatment would challenge any surgical virtuosity. Chronic staphylococcal carriers are at risk whatever blood access is used; one of ours lost 12 blood and peritoneal access sites and one transplant from infection; for such patients prolonged indwelling tubes in the subclavian vein or vena cava have proved life saving, even though their liability to septicaemia persists.13

ADVANCES IN HAEMODIALYSIS 2: SINGLE NEEDLE DIALYSIS.

In the era of the shunt, the dialysis circuit was designed to pump blood out of the arterial end and back into the venous end. When the fistula was introduced, the circuit was simply attached to two needles, a distal (arterial) one and a proximal (venous) one. Several years passed and thousands of fistulas were punctured hundreds of times before it occurred to anyone that it would be kinder to the patient and easier for the staff if we inserted one needle rather than two.14 Kopp’s original solution to this problem was to occlude the venous and arterial line alternately by means of a lever which flicked rapidly across from one to the other. A single blood pump pushed blood into an expanding dialyser for a few seconds then sucked on an empty line for the next few seconds while the dialyser drained into the patient. There were two big disadvantages to this system. Modern dialysers, particularly hollow fibre dialysers, have a low compliance so the system
had to switch back and forth too frequently for efficiency. Some recirculation inevitably occurred at each switch. This problem was overcome very simply by inserting an expansion chamber into the arterial line. The second problem was harder to overcome; to achieve a high blood flow through the dialyser, the drainage phase had to be fast and therefore the pressure in the dialyser had to be kept high. This produced a high obligatory ultrafiltration. The proportionating machines of the 1970's did not have controlled transmembrane pressure, so the ultrafiltration had to be compensated by saline infusion and the risk of hypotension was considerable.

The second problem was elegantly circumvented by the use of a twin-head pump which accelerated the drainage phase and gave the operator complete control over the pressure in the blood compartment; indeed this system permitted the use of high flux dialysers in open circuit for the first time.\textsuperscript{15} Despite the intermittent flow through the dialyser, its efficiency at a given flow rate per minute was the same as that with a conventional two needle, continuous flow arrangement.\textsuperscript{16} Unipuncture proved so popular with patients in Ghent and Newcastle that it was adopted as the standard practice in both centres. However, the extra cost of the twin-head pump has deterred others from using it, and it remains the minority treatment worldwide. The last development has been the marketing of double lumen needles which give a higher flow through the dialyser, and therefore a better dialysis efficiency than tidal flow,\textsuperscript{17} provided the fistula is of sufficient size. Double lumen subclavian catheters bring the same advantages to temporary access but with a greater need to watch for recirculation, by checking the plasma urea in the arterial and venous lines and in a vein of another limb, if there is any suspicion that dialysis efficiency is inadequate. (Kerr's rule-of-thumb is that the post-dialysis plasma creatinine should be half the pre-dialysis or less).

Single needle dialysis is underused. It has been widely adopted in acute renal failure, where it is a godsend to patients with multiple demands on their veins. It had been neglected in the treatment of chronic renal failure, where it is not usually life-saving but is an added measure of comfort, convenience and reassurance to many patients. The reluctance of dialysis staff to change their routine, and take the little extra trouble is, I believe, a bigger constraint on its use than cost. Perhaps this is a sign that doctors on dialysis units spend less time listening to the lesser complaints of their patients than they did when Kopp invented unipuncture.

ADVANCES IN HAEMODIALYSIS 3: PROPORTIONING.

When regular haemodialysis began, we all used recirculating baths. They were cheap, effective and easy to maintain; these qualities have kept them in use in many countries for a decade after they disappeared in the British Isles. However, they had several disadvantages of which the worst was the difficulty of sterilising them between dialyses. Bacterial build-up was a constant threat, and I have seen patients looking slightly seedy as they finished their dialysis against a bath of what looked like pond water and contained \( > 10^5 \) \textit{alkaligenes faecalis} or some other nasty organism per ml.

The first proportioning machine was designed by Babb and his colleagues at Seattle.\textsuperscript{18} It was unveiled at a conference in December 1964 which marked the birth of home haemodialysis. It was not really essential to dialysis in the home, which has been conducted successfully with recirculating systems, but it reduced the drudgery and it stimulated manufacturers to improve the monitoring. The drudgery of home haemodialysis is dismissed too airily by enthusiasts for this.
form of treatment. At that inaugural conference the world's first home dialysis couple were interviewed on television and asked how they spent their evenings. "Mondays, Wednesdays and Fridays, we dialyse" they replied. "Tuesdays, Thursdays and Saturdays we clean up and get ready". "And Sundays?" asked the interviewer. "We flop!". The steady, and very impressive, improvement in the design of proportioning machines, which has largely been the work of industry, has made life for the home patient more tolerable than it was in 1964, though it is still a heavy burden to impose on any family.

ADVANCES IN HAEMODIALYSIS 4: MONITORING.

Monitoring was developed in parallel with proportioning and has not changed fundamentally since the 1960's. The choice of parameters that required constant observation — dialysate pressure, temperature, conductivity and flow rate, venous bubble trap pressure and suction on the arterial line — have proved wise choices. There were three other measurements that clinicians wanted from the start but which proved much harder to provide: ultrafiltration rate, blood flow rate and presence of air or froth in the venous blood line.

The first machine to give a reliable measure of ultrafiltration was the Rhodial, designed to curtail ultrafiltration from the high flux RP6 dialyser. It had a closed dialysate compartment from which the ultrafiltrate was displaced into a measuring cylinder. A miniaturised version of this system has been adopted in other machines designed for single-pass dialysis; the dialysate compartment adjacent to the dialyser can be sealed off for a few seconds during which the ultrafiltrate is measured in a small flow meter.

Several ingenious devices for continuous measurement of ultrafiltration have been built and a few marketed; they have depended on comparing the inflow to and outflow from the dialyser, which differ by about 0.2 – 2.0% depending on the ultrafiltration rate. The very precise measurement of flow rate demanded by this exercise has so far defeated the instrument makers. Consequently some machines calculate ultrafiltration rate from the transmembrane pressure, which is computed from pressure measurements at inflow and outflow of both compartments of the dialyser. The final solution of this problem remains a challenge to the designers.

Accurate measurement of blood flow rate is required for research purposes but not for clinical dialysis. Pump speed gives a reasonable measure of blood flow if there is a monitor to detect excessive suction on the arterial line, and bubble transit time over a measured track is an acceptable check. Consequently no manufacturer has made the necessary investment to provide us with a Doppler or similar blood flow meter which is robust and reliable enough for clinic use — a pity because it would be a help in patient care.

Detecting air in the venous line, on the other hand is a matter of life and death. However, many British clinicians were slow to adopt air-embolism monitors because they rightly believed that the best way to prevent air embolism was to prevent air entering the circuit, by having all infusion points downstream of the pump. The early monitors, which relied on the creation of an uninterrupted light path in the bubble trap or venous line, were easily fooled by froth. However, it is difficult to eliminate some causes of air embolism such as splits in the blood pump inserts or displacement of the arterial needle during sleep, so it would be difficult to justify the omission of an air embolism monitor now that the capacitance and

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Advances in haemodialysis 5: De-aeration.

Cold water contains more dissolved air than warm water. When cold mains water is rapidly heated in a proportioning unit the dialysis fluid becomes supersaturated with dissolved air. The surplus oxygen and nitrogen diffuse through the membrane into the blood which forms bubbles as the pressure is reduced during its passage through the dialyser and into the venous bubble trap. The problem is encountered almost exclusively among home dialysis patients during winter in Northern regions; we saw a lot of it in Newcastle. Some of our home dialysis patients had to wake themselves by alarm clock hourly during the night to empty the bubble trap of froth and prevent air embolism.

The first partly effective de-aerators heated the incoming water rapidly to release air, then cooled it in a heat exchanger. Water temperature rose by about 10°C which caused no problems in Britain but was a challenge to ingenuity in the tropics. One resourceful Singaporean wife solved the problem by filling the domestic bath with "cold" water overnight, then pumping this de-aerated water into her husband's proportioning machine, by-passing the heater and heat-exchanger. Such labours are now unnecessary, for the problem was eliminated by the use of efficient suction de-aerators.

Demonstrating the cause of this problem and persuading manufacturers to take it seriously and overcome it by better design was one of our most satisfying adventures in dialysis. It has now gone from the dialysis unit into the history books.

Advances in haemodialysis 6: Ultrafiltration.

A more important advance was announced by Jonas Bergström at the Hamburg Congress of EDTA in 1976. He described his simple chance observation that ultrafiltration through a dialyser with the dialysate pathway unconnected allowed rapid removal of fluid without the haemodynamic disturbances seen during haemodialysis. The Chairman, Dr Stanley Shaldon, congratulated him on "... the most important paper I have heard in the dialysis field in the last decade". It was no exaggeration. Bergström's observation has been abundantly confirmed and widely applied in the emergency treatment of fluid overload in both acute and chronic renal failure.

Bergström went on to develop the technique of sequential ultrafiltration-haemodialysis which sought to avoid dialysis hypotension by separating fluid removal from solute removal. There is much anecdotal support for this widely used method, but our own controlled trial failed to show any advantage over conventional haemodialysis. It could be criticised because the patients were unselected, not chosen because of their liability to dialysis hypotension, but I am unaware of any subsequent trial that has overturned the verdict.

Whatever the eventual place of sequential ultrafiltration it brought us one great advance. Its use led manufacturers to develop proportioning machines with controlled transmembrane pressure so that the doctor, nurse or home patient can control ultrafiltration at will.

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ADVANCES IN HAEMODIALYSIS 7: DIALYSER DESIGN.

One of the nightmares of the 1960's was building the Kii dialyser and then waiting on tenterhooks for the air-pressure test that so often signalled a membrane leak and the need to start again from scratch. At the inaugural conference on home dialysis a doctor who was himself a dialysis patient looked at the first proportioning machine with all its monitoring and exclaimed "Don't make me feel like spaceman, just design a dialyser that does not leak". Long after the first man walked on the moon we had coil dialysers with a 10% leak rate. Today a leak rate of 0.1% is not exceptional and we owe a great debt to Werner Bandel and his successor at ENKA AG who perfected the manufacture of Cuprophan and first gave us leak-free membranes.

One of my privileges since 1970 has been to work with the manufacturers of dialysers, test their products, advise them on design improvements and report the findings to the Department of Health and Social Security who distributed them to renal units. The architect, and often the artisan, of our studies was Dr N A Hoenich whose work has recently been summarised in a DHSS Bulletin.25

There was a period of excitement and intense activity in the early 1970's reminiscent of the early 1900's in motor car design or the last decade in computer technology. Small companies sprang up and bright ideas tumbled off the drawing boards in rapid succession. Untroubled by the entanglement of regulation which now emeshes the designer, they experimented freely with new materials and in 3 short years doubled the performance of the artificial kidney. DIY doctors joined in the fun; the most important advance in membrane supports was the work of Dr Holtzenbein who spotted an interesting plastic mesh in the upholstery of his Volkswagen. The pace of advance has slowed, but the need for it has also diminished. Today's dialysers are compact, convenient, reliable and efficient; their cost (corrected for inflation) is about one-twentieth that of the first disposable dialyser.

ADVANCES IN HAEMODIALYSIS 8: WATER TREATMENT.

The British renal failure services started on a shoestring and has swung on it ever since. One disastrous result was the conscious decision that, when treatment was limited by funds, we could not spend part of our limited budget on the cost of full water treatment. By 1973 I had come to doubt the wisdom of this policy, and at a meeting on water for dialysis26 I admitted that we had no proof that water treatment prevented any of the complications of dialysis, but said that I visualised myself one day standing in a court of law and conducting a conversation with the prosecuting counsel which ran like this:

Counsel: My client claims she has bone rot (and) brain rot... because you are making her dialysis fluid with impure water.

DNSK: We use only the best tap water supplied by the Newcastle and Gateshead Water Company and passed fit for human consumption.

Counsel: My client says you give her 300 times as much water through her dialyser as the average citizen drinks....

DNSK: Our tap water is not known to contain anything that causes bone rot and brain rot....

Counsel: Does it contain no identified impurities?

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DNSK: It contains some . . . (I listed the many sources of impurities in tap water from the Cheviot Hills to the taps and finished . . . ) . . . we put flocculating agents into our water to get rid of the colour, chlorine to get rid of the bacteria, fluoride to help the bairns' teeth . . . .
Counsel: No doubt you monitor all these impurities regularly . . . ?
DNSK: No, but we get an annual report from the Water Company . . . .
Counsel: Are you sure that none of the substances you study in so cavalier a manner are harmful?
DNSK: No, but we are studying them . . . .
Counsel: When do you hope to complete these studies?
DNSK: Maybe in 50 years' time.
Counsel: By that time the answers will have ceased to interest my client.

I concluded “Because of this sort of consideration, rather than because the case is proven, I suspect that all of us will eventually decide to err on the side of safety (and expense) by removing all contaminants and forgetting about them”.

My suspicion proved unfounded. My own Health Authority was unconvinced by the argument; we continued to use water softeners as our main method of water purification and in Newcastle alone 27 patients suffered the brain rot to which I alluded and 23 died; about 200 suffered disabling illness from the bone rot, now known as aluminium osteodystrophy. The story was repeated all over Northern and Western Britain. Like the road users who are protected from an accident black spot only when enough people have died at it, our patients received the protection of adequately purified water only after an unacceptable sacrifice that could have been foreseen and indeed was foreseen and predicted.

Now the threat of encephalopathy and disabling bone disease has been removed and as a by-product the other, less important identified impurities like fluoride, chloramines and lead can be forgotten.

ADVANCES IN HAEMODIALYSIS 9: FREEDOM FROM FEAR.

Many fears haunted the pioneering patients in this form of treatment, not least the fear of death. Some of these fears have been largely removed.

Hepatitis B was a real menace to patients and staff in the 1960's and 1970's. It was largely eliminated from British units by rather draconian hygienic measures, isolation of carriers and, in a few cases, refusal to accept hepatitis carriers for dialysis. The fear of hepatitis reached ludicrous lengths. I remember sacks of perfectly functioning or readily reparable telephones on their way to the incinerator because they had been in the home of a dialysis patient, often one who was more certainly free of hepatitis than the telephone engineer who removed them. Specific immune globulin and vaccination against Hepatitis B have removed much of the fear and given our patients once again the freedom to travel abroad on holiday, though sadly the shadow of AIDS now hangs over that newly-found freedom. I welcome the chance to say “Thank you” to the many kind donors who provided holiday homes around Britain and to Mrs Elizabeth Ward who had the imagination to provide hepatitis-free holiday centres in Britain and abroad through the BKPA, for giving our patients the chance of a much-needed break in the days when fear of hepatitis kept them at home.

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Dialysis itself was once greeted with foreboding. In the 1960's it was common to see most of the patients in a dialysis session vomiting into their kidney dishes. Cramps were a common and miserable accompaniment of dialysis. Headache during the procedure and lassitude after it were almost universal. We have learned a lot about the causes of these complications but not enough to explain the dramatic fall in their incidence. With no proof to back it up, it is my strong hunch that many of the symptoms were caused by contaminants in dialysis fluid, dialysers, circuits etc which have been eliminated by better equipment and techniques without our ever identifying them. Copper, zinc and nickel from metal parts in contact with feed water or dialysate, plasticizers from tubing and silicone particles from blood pump tubing have all been identified as causes of acute or chronic symptoms, and it is anyone's guess how many more transient contaminants have done their harm and disappeared undetected.

Pyrogen reactions were a particularly nasty complication of dialysis. They usually started within the first hour of dialysis, caused angor animi, chest pain, rigors and general misery which slowly subsided over the few hours after the temperature peaked. Crops of facial herpes were a nearly universal sequel. In the literature of the 1960's and 1970's they were nearly always blamed on bacteria or pyrogens contaminating the dialysis fluid, although their timing and epidemiology were seldom in favour of this theory and several authors failed to demonstrate passage of pyrogens across dialysis membranes. Pyrogen reactions complicated 30% of dialyses in our first year at Newcastle, when we used non-disposable blood circuits and several subsequent outbreaks were traced to contaminants in the blood pathway. I believe that the virtual disappearance of this frightening complication of dialysis is due to the use of disposable dialysers which are now manufactured with stringent precautions against contamination with pyrogen. Whatever the reason, patients no longer have to endure or fear them.

ADVANCES IN HAEMODIALYSIS 10: ESCAPE TO ALTERNATIVES.
CAPD has arrived to give the haemodialysis patient an alternative if it suits his lifestyle better or if his vascular access sites are used up. However, the biggest single change in his lot is the greater chance of successful renal transplant. It is here that Belfast has made its greatest, and all-important, contribution. By maintaining a high success rate throughout, by reducing morbidity with the low-steroid regime and by providing almost enough transplants to provide for the needs of its Region, Belfast has inspired the rest of the UK during the years when we trailed behind.

ADVANCES IN HAEMODIALYSIS 11: BETTER MEDICAL UNDERSTANDING AND CARE (The Belfast factor).
In this talk I have concentrated on the technical advances which have had immediate and visual impact on the results of regular haemodialysis. Of equal importance has been a growing medical knowledge of what is involved in "life after renal failure". That knowledge now generates a new edition of Drukker, Parsons and Maher27 every 3 or 4 years, its 49 chapters bearing an average of about 200 references to original articles. It is to this corpus of medical knowledge, rather than to the technical details, that the Belfast team has made its many contributions. With a fine blend of scientific curiosity and concern for patients they have looked at practical problems like gastrointestinal bleeding, seeking its cause in the pathophysiology of the hormones governing gastric secretion28 and applying that knowledge to the prevention of the disease.29

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Above all, however, we acknowledge that the Belfast contribution is the maintenance of the highest clinical standards in medical care. That is the only explanation that has been found for the outstanding success of the Belfast transplant programme, and it also accounts for the success of their dialysis programme.

**ENVOI**

On the 25th anniversary of the foundation of the Belfast Renal Unit, I say to Mollie McGeown and her fellow pioneers: "It has been a wonderful quarter century to live through; we have seen the transformation of this form of treatment, and it owes a lot to your example. It has been fun and inspiration to share these years with you and I hope your next 25 years, and ours, will be just as rewarding".
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