PART XII

WORKSHOP ON SINGLE NEEDLE DIALYSIS

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SINGLE NEEDLE DIALYSIS

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Introduction

The currently preferred method of circulatory access for patients receiving regular dialysis treatment, is by an arteriovenous fistula into which two needles are inserted at each treatment. A single venepuncture is preferable from both the patients' and the dialysis unit staff's point of view, since the insertion of a second needle is often difficult and painful.

The technique of single needle dialysis may be performed either by the use of mechanical systems which generate an intermittent cyclic flow pattern through the extracorporeal circuit, and involve the use of a single pump in conjunction with reciprocating occlusive clamps, or twin occlusive roller pumps. Alternatively, a double lumen catheter may be used.

This workshop brought together exponents of each of these techniques who reviewed their experiences.

Potential drawbacks of mechanical single needle systems

Kopp reviewed the current problems that remain with such systems despite the technological advances made since their introduction in 1971. These problems are: lowered dialysis efficiency from recirculation, a feature of all systems of single needle, the magnitude of which depends on fistula flow; compliance of blood lines and operating parameters; a poor control of ultrafiltration in single pump tidal flow systems compared with good control in double pump systems, and the existence of back ultrafiltration under certain operating conditions. Some systems may also have safety hazards or operational problems associated with their use, resulting from their design.

To overcome these limitations a single needle system has been developed based on a commercially available system. The basis of this system is a self-regulating crossover control of the blood line clamps by both the maximum blood pressure of the cannulated vessel and the maximum blood return pressure.

In addition to the conventional arterial pump, a venous blood return pump is included to isolate the blood compartment of the dialyser from the pressure on the venous outflow line, a feature common to a number of commercially available double pump single needle systems, but contrary to such systems, these two pumps operate in a continuous normal speed mode and not in an intermittent double pump speed mode, and consequently the blood compartment pressure of the dialyser is not subject to the oscillations between the maximum and minimum set points, but is maintained in almost a linear fashion at any desired level. The benefits offered by this solution are: automatic response to any changes of fistula flow, clinically acceptable recirculation, adjustment of the blood pump rate to the maximum flow rate of the cannulated vessel and the elimination of the problem of obligatory ultrafiltration.

Clinical experience with single needle dialysis

Harrison recounted nine years experience using a single pump tidal flow system operated by a time/time controlled switching mechanism. The need to preserve vascular access and patient comfort being the reasons for the initial adoption of this technique of treatment which is now used in over 100 patients, it is, however, subject to a number of problems. Firstly, the venous return to the patient is driven by the pressure head generated within the dialyser, which imposes high ultrafiltration rates at high blood flow rates. Modifications to the extracorporeal circuit, when used with hollow fibre dialysers are necessary and in consequence, use of this system is confined to flat plate haemodialysers. Despite these limitations, the objectives of a good dialysis, patient benefit and the preservation of access site are considered to have been achieved.

While the use of single pump tidal flow systems is declining, the availability of double pump tidal flow systems from a number of haemodialysis equipment manufacturers over the past few years has meant that their clinical use has increased.

Brown described the advantages and clinical benefits of using one such system in a busy haemodialysis centre which performs 35,000 treatments per annum. His indications for use of single needle were poor fistulas, not in terms of the flow obtainable, but in terms of usable length and the ability to insert two needles. The technique was also applied to the treatment of acute renal failure, since in many cases it was not always possible to insert shunts, and subclavian catheterization when used with single needle systems was a quick and effective technique.

Dibble described the reasons for the increased utilization of single needle systems in adults compared to children at Leeds, where paediatric dialysis was routinely performed using a single pump tidal flow system. In the past 18 months, however, there has been a shift away from use of such systems in favour of the double pump tidal flow systems, whose use has also been extended to adult patients in both the home and hospital.

In this instance, the reasons for increased utilization of the technique were: convenience, clinical acceptability, and the absence of penalties in respect of

extra time for treatment due to the influence of recirculation. Despite these benefits, use of single needle dialysis using double pump tidal flow systems is by no means elective for all patients treated either in the home or hospital, with its use confined to patients with needling problems, as well as to those with vascular prosthesis.

Whereas in some centres there has been a reluctance to utilize this technique in home haemodialysis patients, the Leeds experience demonstrated that patients trained from the start using such a system in the home, took no longer to train than those who were training with the conventional two needle vascular access technique. In patients who originally trained with two needle vascular access, and subsequently transferred to single needle dialysis, a small number have, however, found the mastering of the concept difficult.

Paediatric dialysis

In the first of two presentations dealing with the use of single needle dialysis in children, Winterbourn reviewed his experience of treating 58 patients since 1979, of whom 33 had received regular dialysis treatment ranging from two months to five years.

Treatment ranged between three to four hours, three times per week, and there was a policy from the onset of treatment that single needle dialysis would be used in this group of patients. Of the 33 patients who are currently on haemodialysis, about 20 are receiving treatment in their own home. Originally, a time/time or pressure time single pump tidal flow system was used, but more recently the emphasis has been on the use of double pump tidal flow systems, due to the benefits and flexibility that such systems offered. The aim of treatment was to provide a urea clearance of 3–5ml/kg body weight, and the clinical results obtained were acceptable, although in three cases of patients receiving twice weekly haemodialysis, uraemic pericarditis had occurred. He alluded to the problem of needle phobia which occurs frequently in such treatment groups. The solution of this problem being accomplished either by the use of subclavian catheters in conjunction with single needle systems, or by hypnosis with conventional single needle access.

In the second of the presentations dealing with paediatric dialysis using the single needle systems, van Damme-Lombaerts described the experiences accumulated since 1976 using a double pump pressure-pressure system with 22 children treated during this period.

In a series of measurements assessing clearance, recirculation and extraction ratio in patients receiving single and double needle dialysis, it was found that despite the high recirculation observed in some patients there was no clinical sequelae resulting from inadequate dialysis, and indeed, results obtained for clearance of urea and creatinine were comparable to data established with conventional two needle dialysis. Furthermore, the comfort offered by the technique was an important factor in the acceptance of dialysis by children.

Adequacy of treatment when using single needle techniques

A widely held belief is that single needle dialysis is less efficient than conventional double needle dialysis. This assumption is based largely upon clinical data gained using the earlier single pump tidal flow systems.

Van Holder, in his presentation, described the use of kinetic modelling for the calculation of urea distribution volumes, urea generation rates and protein catabolic rates in a group of 76 patients receiving regular dialysis treatment at Gent, using a double pump pressure-pressure operated system.

He showed that the time integrated urea clearance results for the group of patients receiving single needle dialysis treatment were comparable to that described in the literature for efficient two needle dialysis techniques, indicating that the elimination of small molecular solutes by this technique is efficient. Urea distribution volumes, urea generation rates and protein catabolic rates were also comparable with patients having a comparable protein intake and receiving two needle dialysis. These results are in agreement with what one would expect from well dialysed patients.

Double lumen catheters

Subclavian catheterization is used extensively in the treatment of both acute and chronic renal failure. Their use is, however, dependent on the single pump tidal flow systems.

Tapson reviewed two recent alternatives to this widely used method of circulatory access, namely the co-axial or double lumen subclavian catheter and the more recent dual lumen subclavian catheter. Double lumen subclavian catheters offer a low recirculation and permit the attainment of a high blood flow rate but at the expense of unacceptably high venous pressures, thus limiting their clinical usefulness. Furthermore, because of their large size, they may be difficult to position, the inner lumen may need regular replacement and the device may be subject to clotting.

The Shiley and the Quinton-Mahurkar dual lumen subclavian catheters offer an alternative to double lumen catheters. Their basic design is comparable. A central septum divides the catheter into two separate non-communicating blood pathways. Blood is drawn into the catheter via a series of access holes and returned through the tip of the catheters and through side holes. Each lumen is independently connected by a small segment of tubing with luer locking caps.

Clinical studies with such catheters have indicated low recirculation rates, low venous resistances, and the attainment of clinically acceptable blood flow rates. Furthermore, clotting was not a problem with either of these catheters.

While the catheters were haemodynamically acceptable, a poor reliability was noted with approximately one-third of the catheters having to be removed due to a basic design problem, namely that the arterial access holes are blocked by endothelium when negative pressures are applied.

Whereas the haemodynamic characteristics of such catheters make their performance superior to other currently available forms of subclavian vascular

access, clinical evaluation recommends that their use in patients is confined to acute haemodialysis situations.

The role of single needle dialysis in current clinical practice

Current use of mechanical systems of single needle dialysis appears to be confined largely to specific situations such as paediatric dialysis, the treatment of patients who have a well-functioning fistula but who have only a small usable segment available for needling, or who have vascular prostheses. Dual, or double lumen catheters, on the other hand, are best suited for short-term clinical use such as the treatment of acute renal failure or the provision of temporary access for alternative treatments such as plasmapheresis, haemoperfusion or isolated ultrafiltration.

With the availability of double pump single needle options from a number of haemodialysis equipment manufacturers, which when used under optimal operating conditions, offer a high degree of patient acceptance, safety, minimal recirculation and dialysis efficiency comparable with that achieved when using conventional two needle access, routine clinical application of this technique to all patients with end-stage renal failure should receive serious consideration.

Note

The addresses of those presenting data at this workshop who are mentioned in the text can found in the Author Index.