

Some Problems:

The Use of Internal Arteriovenous Fistulas

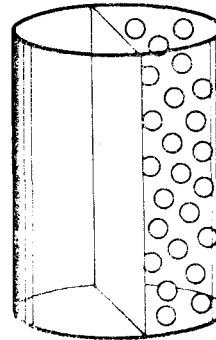
In Chronic Hemodialysis

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ABSTRACT

Increasing use of the internal A-V fistula for hemodialysis calls for re-emphasis of details of the original technic described by Brescia, Cimino et al. Needles should be well separated, even sometimes with a tourniquet between them to avoid possible mixing of outlet with inlet blood. Needles should not be less than 14 gauge (thin wall), with maximum blood pumping speed not over 250-275 ml/min to avoid trauma to vessels, and risk of air leaks in the blood circuit.

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Since its description by Brescia, Cimino, Appel and Hurwich (1) in 1966, the venipuncture technic in conjunction with a surgically created internal A-V fistula has become an accepted means of access to the blood stream for persons undergoing regular hemodialysis (2). Clotting and infection, problems which often limit the usefulness of the standard Quinton-Scribner external shunt are almost eliminated by the internal fistula (3,4). As an estimate, several hundred of the approximately 3000 persons being dialyzed in this country, in centers and at home, now have internal fistulae.

However, as it was the case with the teflon-silastic cannulae, the use of the method in many different centers has led to deviation from the original technic (5). It is our purpose to call attention to some technical details of dialysis via the internal fistula, which if unappreciated, result in inadequate dialysis for the patient.

We first became aware of some of the problems that can occur with internal A-V fistulae when two of our chronic center patients failed to lower their extremely high serum creatinine levels in spite of a very low serum creatinine in the arterial line of the kidney at the end of the dialysis procedure. We had been misled by our routine of drawing samples from the arterial line just as dialysis was begun and again from the same site at the end of the run. The apparently reduced serum creatinine levels suggested adequate hemodialysis had been accomplished during an adequate dialysis time.

CASE REPORTS

Patient 1 was an 18 year old female who weight 35 kg. and dialyzed with a 145-coil three times per week at six hours each. Maximum flow rate achieved in this patient was 275 ml/min. Pre-dialysis creatinine values were 18-20 mg% in spite of 7 mg% after each dialysis. She tended to be acidotic and was frequently hyperkalemic.

Patient 2 was a 36 year old female who weighed 55 kg. She also was dialyzed with a 145-coil three times per week for a total of 15 hours. Maximum flow rate achieved in this patient was 315 ml/min. Her pre dialysis creatinine remained at 15-20 mg% and she did not feel well. On 10-17-1967 her pre dialysis BUN was 124 mg%, creatinine 14.4 mg%, pH was 7.30, CO₂ 11 mEq/L, pCO₂ 40 mmHg, pO₂ 48 mm Hg. At the end of dialysis the values were: BUN 40 mg%, creatinine 6 mg%, pH 7.33, CO₂ 6 mEq/L, pCO₂ 34 mm Hg, pO₂ 46 mm Hg. The unlikely possibility of failure to metabolize Acetate was considered. Shortly thereafter she received a successful renal allograft and no further dialysis was needed.

In both these patients the serum creatinine levels just prior to their next dialysis indicated that in reality a poor dialysis had been accomplished previously.

However, in calculating the dialysance values in both patients, it was noted that their figures were significantly lower than those for other patients in the same study. Their bath concentrations were some 50 percent lower than those of other patients with comparable blood values.

TABLE 1

mg/100 ml	FA	A	V	B
Glucose	342	342	714	900
Urea-N	14	14	10	1
Creatinine	4.3	4.8	3.9	1.5

	FA	A	V	B
	210	214	480	900
	60	51	46	1
	17.4	9.9	9.7	1.5

LEGENDS

FA = femoral artery
 A = arterial line
 V = venous line
 B = dialysis bath
 QB = blood flow

	FA	A	V	B
	262	396	600	1240
	98	85	27	3
	12.8	10.8	6.8	1.9

IN VIVO STUDIES

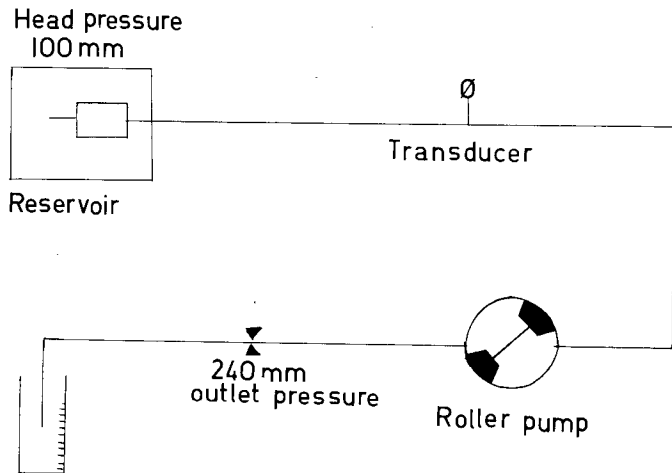
Among 10 patients with internal A-V fistulae four did not do well on chronic hemodialysis. Six other patients had none of these problems mentioned above. It was speculated that the outflow blood from the dialyzer was being shunted into the inflow needle. A relatively small volume of extracorporeal blood would be effectively dialyzed as indicated by the A-V difference, but the total quantity of patient's blood passed through the dialyzer would be less than indicated by the blood flow rate. This would account for the low extraction of creatinine and explain the apparent failure of utilization of acetate by the second patient.

Four patients were therefore studied by simultaneous sampling from the arterial and venous lines, contra-lateral femoral artery, and bath for content of glucose, urea and creatinine. Bath glucose concentrations of 900 to 1200 mg/100 ml were used. Table 1 shows the results of three of the four patients.

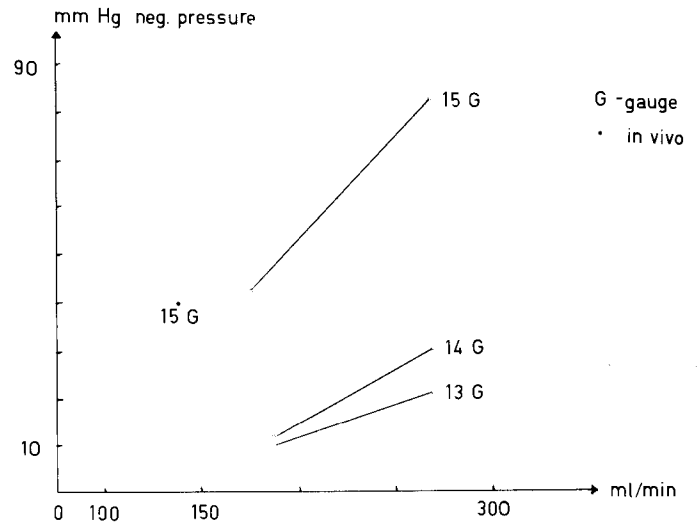
Patient A had the needles 12 cm apart with a tourniquet between them. The insignificant difference of femoral artery

and arterial line of the coil indicate that there was no evidence of shunting. In contrast, the data of patient B whose needles were 13 cm apart and separated by a tourniquet suggest mixing of blood between the arterial and venous needle as seen in the considerable difference of femoral artery and arterial line creatinine and urea values. Patient C had the needles only 6 or 7 cm apart and without a tourniquet. These data are not conclusive but suggest shunting. Patient D, not shown on this table, whose needles were 22 cm apart showed no evidence of mixing with or without a tourniquet.

These findings confirmed that when arterial and venous needle are close together in the same vessel, or in major branches of the same vessel, mixing of blood from the out-flow of the dialyzer to the inlet needle can indeed occur. Blood in the extracorporeal circuit is in effect recirculated, with at least partial by-pass of the systemic circulation. An apparently satisfactory dialysis procedure actually provides very poor dialysis for the patient.



Graph 1.: In vitro set-up for determination of limiting flow rates



Graph 2.: Negative pressures at different flow rates with different needle sizes

IN VITRO STUDIES

At the time this problem was encountered, the standard needle used in most instances was a 15 gauge thin wall, with an attached 10 inch length of PVC tubing and a female Luer adapter.

In vitro studies were done to determine the limiting factors on flow through this and other needles. A Statham transducer was attached to a T-connection between the needle and the arterial line. The needle was placed in a container of water with a head of pressure at 100 mm Hg. A properly occluded roller pump was operated against an outlet pressure of 240 mm Hg. The flow rate was determined by a collection of effluent in a graduated cylinder. (Graph 1).

As expected, Graph 2 illustrates that all three tested needle sizes (13, 14 and 15 gauge) demonstrated an increase in negative pressure as the flow rate was increased. But the 15 gauge needle had the highest increase in negative pressure as flow rate was increased.

In a single clinical study, the mean pressure in the "arterialized vein" was 80 mm Hg. At a blood flow of 140 ml/min, a negative pressure of 34-45 mm Hg was recorded with a 15 gauge needle, suggesting accentuation by the viscosity of blood.

From these observations, the decrease in lumen diameter from 14 gauge to 15 gauge appears to be crucial. For a normotensive patient with a mean "arterial" pressure of 80-100 mm Hg, pump rates of 270-300 ml/min may produce negative pressures similar to those seen in the in vitro experiments.

CONCLUSIONS

These negative pressures may result in 1) sucking the vessel wall against the needle tip, traumatizing the intima, 2) increase the chance of retrograde flow from the outlet needle to the intake needle and 3) result in excessive negative pressure along the arterial tube. This can produce air leaks at joints and junction points in the tubing and can result in massive quantities of air entering the dialyzer (5). This was seen on three occasions in our center.

The use of a plastic or teflon sheath needle, similar to the Jelco (R) or B-D Longdwel (R), has the obvious advantage of a considerable degree of flexibility and absence of a sharp

tip to damage the vessel. Lateral perforations near the tip are helpful. Unfortunately such needles are expensive and are somewhat awkward to connect to the dialyzer lines.

Although our problems occurred with the first group of our fistulae patients in 1967, our observations emphasize the importance of all points described in the original report by Brescia et al, as to the use of 14 gauge needles, well separated, with a tourniquet between them and indicate pitfalls encountered by not heeding them.

It is advisable that the needles be kept at least 10 cm apart, and a tourniquet be placed between them. It is probably not worth while to attempt blood pumping rates in excess of 250-275 ml/min because of increasing risk of damage to the vessel and/or air leaks into the system with rising negative pressure.

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