STUDY REPORTS

1. Title: Fluid Compartmentalization Studies during Peritoneal Dialysis

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Objective To measure by isotope dilution technique the magnitude and direction of changes in total body water, extracellular fluid, and blood volume that are produced in patients undergoing peritoneal dialysis.

Description In addition to the correction of biochemical abnormalities, peritoneal dialysis has been found to be capable of removing significant amounts of fluid from patients during the procedure. This is usually a desirable therapeutic effect since the majority of patients requiring dialysis have some degree of overhydration.

Since peritoneal dialysis produces changes in water balance more slowly than hemodialysis it is generally regarded as a safer procedure. Nevertheless peritoneal dialysis is an extremely effective method of removing fluid and in several instances has produced hypotension and even frank shock. It has been assumed that the development of hypotension was due to hypovolemia secondary to delays in the adjustment of fluid volumes between the various fluid compartments that exist in the body.

This study is designed to measure these changes in fluid compartments immediately before and after peritoneal dialysis to obtain the net balance or change. The patients who were studied were those requiring dialysis for uremia. All patients were dialysed for 36 hours at a flow rate of two liters per hour. This duration and flow rate are the most widely used and hence the data obtained would be appliable to most other patients undergoing peritoneal dialysis. Standard peritoneal dialysis solutions that are commercially available were used in all patients. These solutions are isotonic to extracellular fluid in electrolyte content except for the addition of 1.5% glucose. The additional glucose content increases the osmolality of these solutions to 371 Osm/liters and thus favors the removal of fluid from patients who have increased serum osmolality, as do most uremic patients.

Plasma volume was measured with radioiodinated serum albumen (RISA). Red cell mass was determined by the volume distribution of chromiunm^{51} tagged red cells. Whole blood volume is expressed as the sum of the Cr^{51} red cell mass and the RISA plasma volume. Total body water was meansured by tritium dilution and the extracellular fluid volume was measured using sodium sulfate (S^{35}). Precise methods used in these procedures have been previously published.

Progress A total of ten patients have been studied immediately before and after periteneal dialysis at the flow rate of two liters per hour for 36 hours duration. In several instances the patients condition required variations in flow rate, duration of dialysis or changes, in the dialyzing fluid-hence are not included in the data on these 10 patients.

Figure 1 depicts the changes in plasma volume. The mean change for this group of patients was a decrease of 505.2 ml $\pm$ 237 ml. This represents a 16% decrease in plasma volume during the procedure and a statistically significant change (P = .001). Figure 2 demonstrates a slight decrease in red cell mass which is not statistically significant.

The change in whole blood volume shown in Figure 3 represents the sum of the changes in the red cell mass and plasma volumes. The mean decrease of562ml $\pm$ 267 ml is statistically significant (P.001), but 90% of the change is due to the decrease in plasma volume.

These studies document the hypovolemia that is produced in these patients during peritoneal dialysis using standard solutions and flow rates. Clinical evidence of hypovolemia such as tachycardia and hypotension could not be detected nor could these changes in plasma volume and whole blood volume be detected by serial hematocrit values. The mean increase in peripheral hematocrits, 1.3 vol%, was not statistically significant. The hypovolemia was produced gradually over a 36 hour period during peritoneal dialysis. This may permit the patient to compensate for this reduction in blood volume without showing signs of clinical deterioration. The magnitude of the decrease documented in these studies demonstrates the precarious position that these patients are in at the end of the procedure, and any further reduction in blood volumes would most likely exceed the compensatory mechanisms. Thus, if more hyperosmotic solutions (i.e. 7.5% glucose) or faster flow rates which increase the efficiency of water removal are used, hypotension and shock should be expected.

The changes in total body water and extracellular fluid are depicted in Figures 4 and 5. The mean decrease in total body water is significant (2.688 liters p .001) as is the decrease in extracellular fluid (2.102 liters p .001) The decrease in extracellular fluid accounts for the majority of the change in total body water, since this is the more readily accessible milieu. The decrease in total body water correlates well with the weight change that was noted in these patients. Although the intracellular fluid volume cannot be measured directly, the difference between the changes in E.C.F. and T.B.W. implys that the intracellular fluid is also decreased during the procedure and accounts for more than 20% of the volume change.

These changes in fluid compartments support the clinical impression that hypovolemia is the cause of the hypotension that sometimes complicates peritoneal dialysis. The mangnitude of the changes suggests that appropriate fluid replacement should be used except in those instances where removal of excess fluid and the correction of overhydration are desired therapeutic effects.

It is anticipated that a similar group of patients will be studied in which fluid replacement will be given throughout the procedure to determine if these volume shifts can be avoided or at least minimized.

Fig. I. CHANGES IN PLASMA VOLUME DURING PERITONEAL DIALYSIS

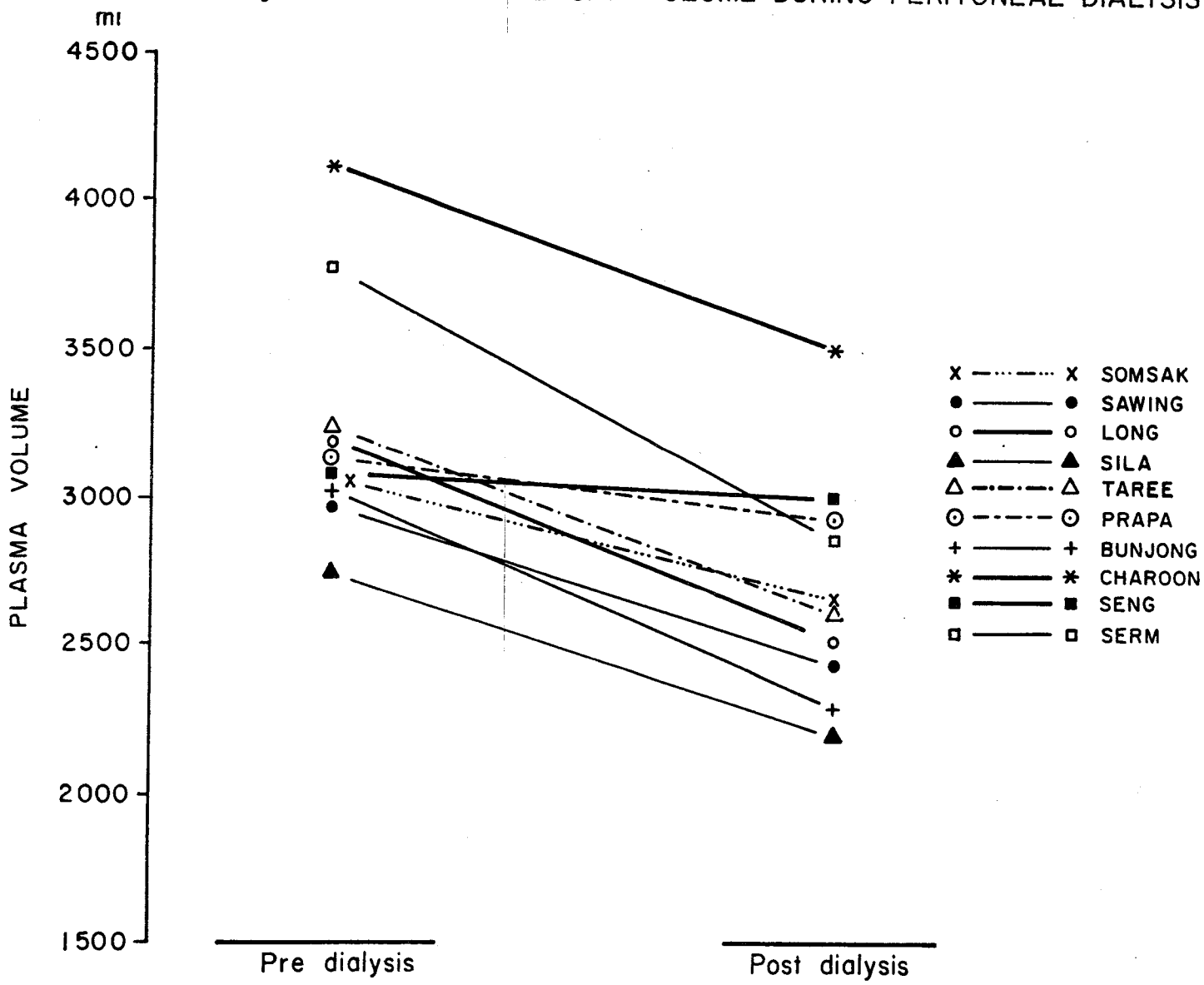

Fig 2 CHANGE IN RED CELL MASS DURING PERITONEAL DIALYSIS

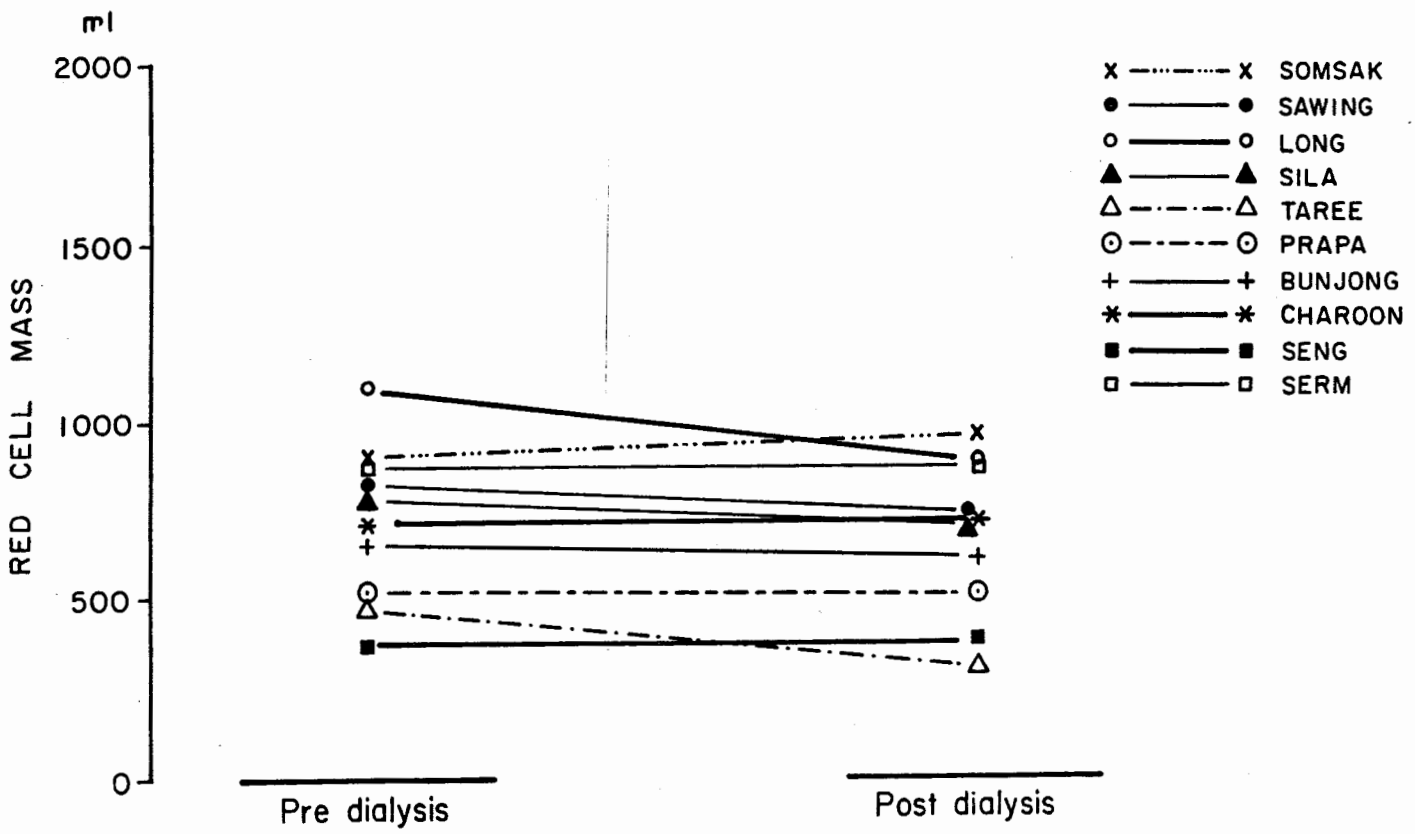

Fig. 3 CHANGES IN TOTAL BLOOD VOLUME DURING PERITONEAL DIALYSIS

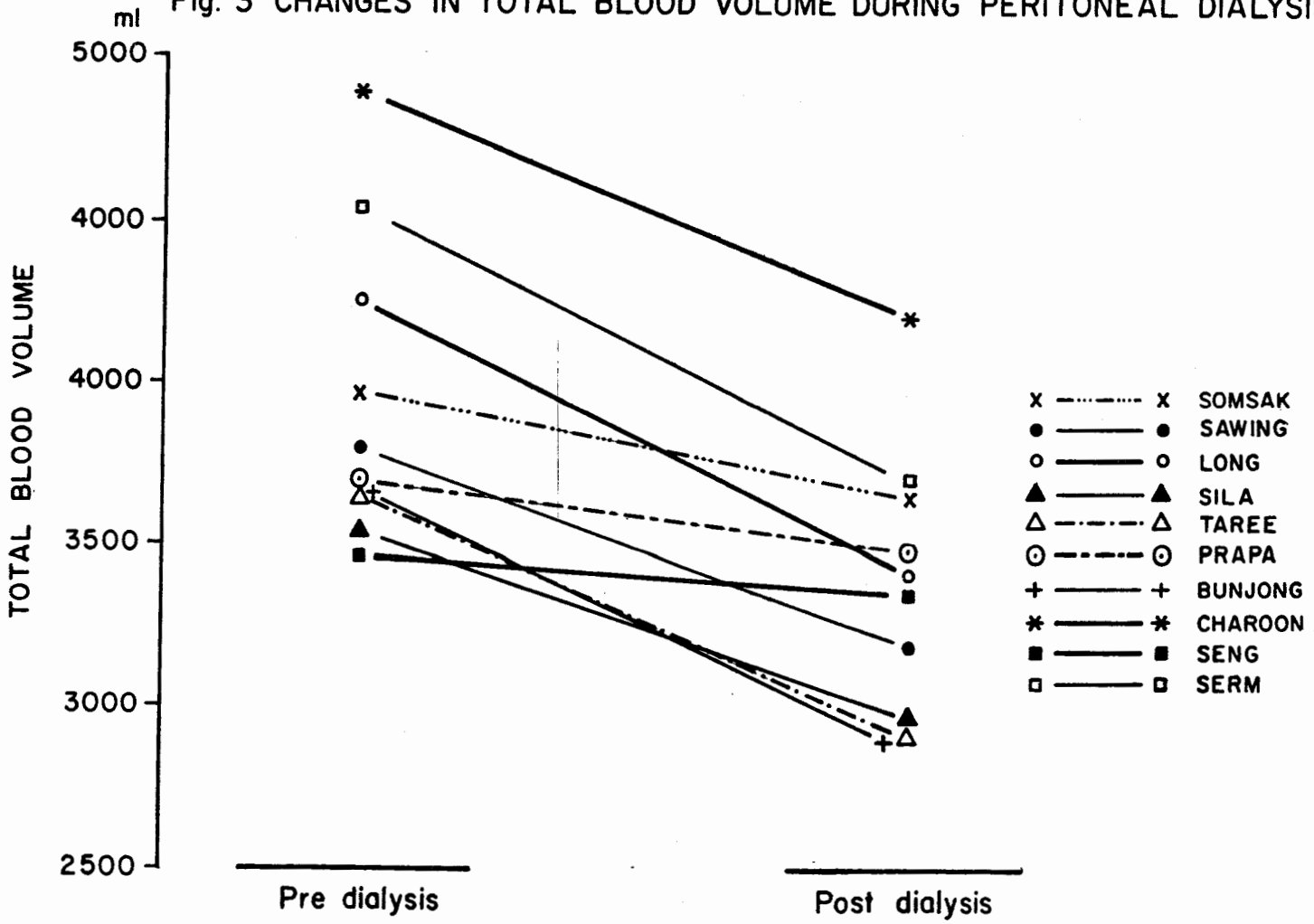

Fig. 4 CHANGE IN TOTAL BODY WATER DURING PERITONEAL DIALYSIS

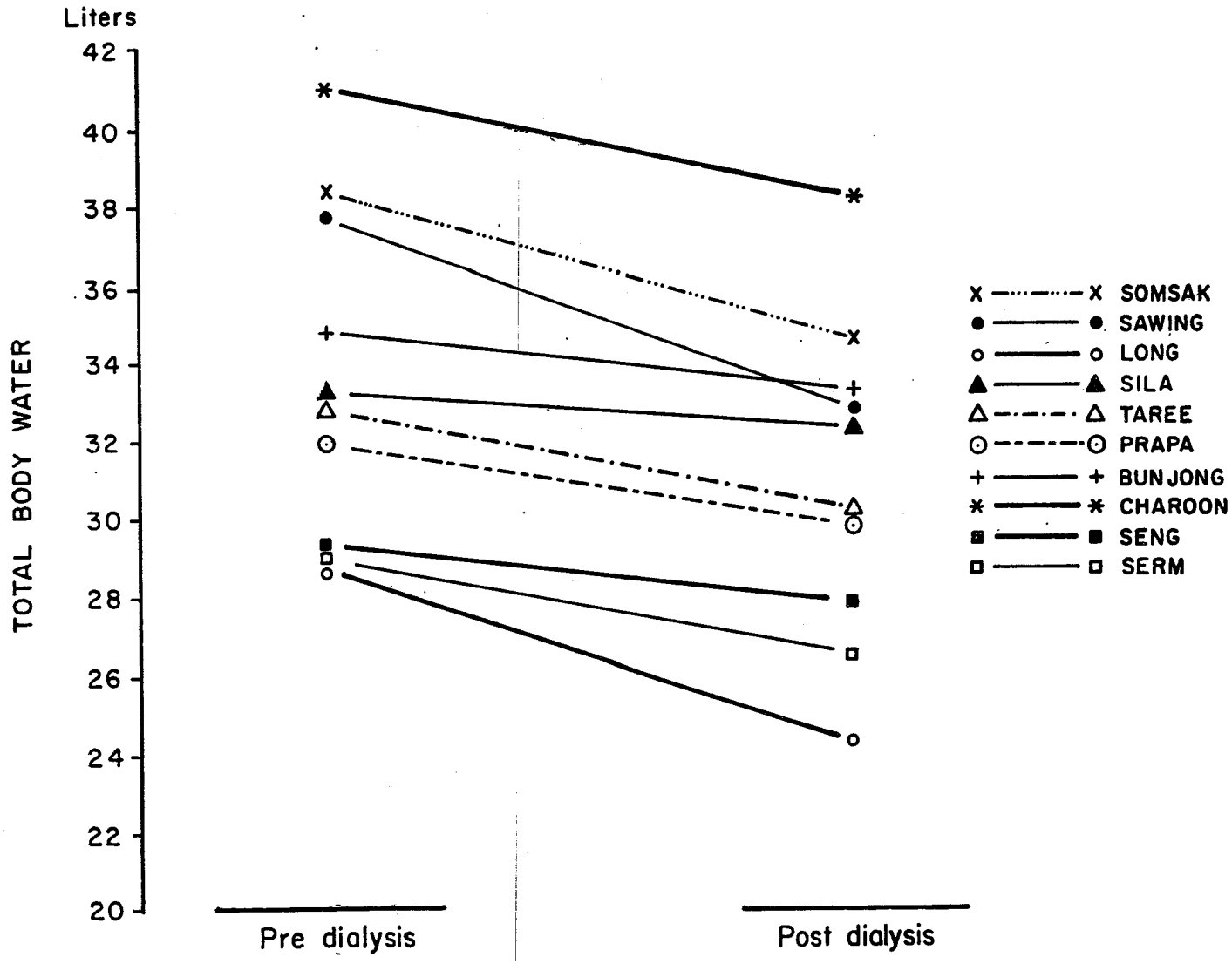
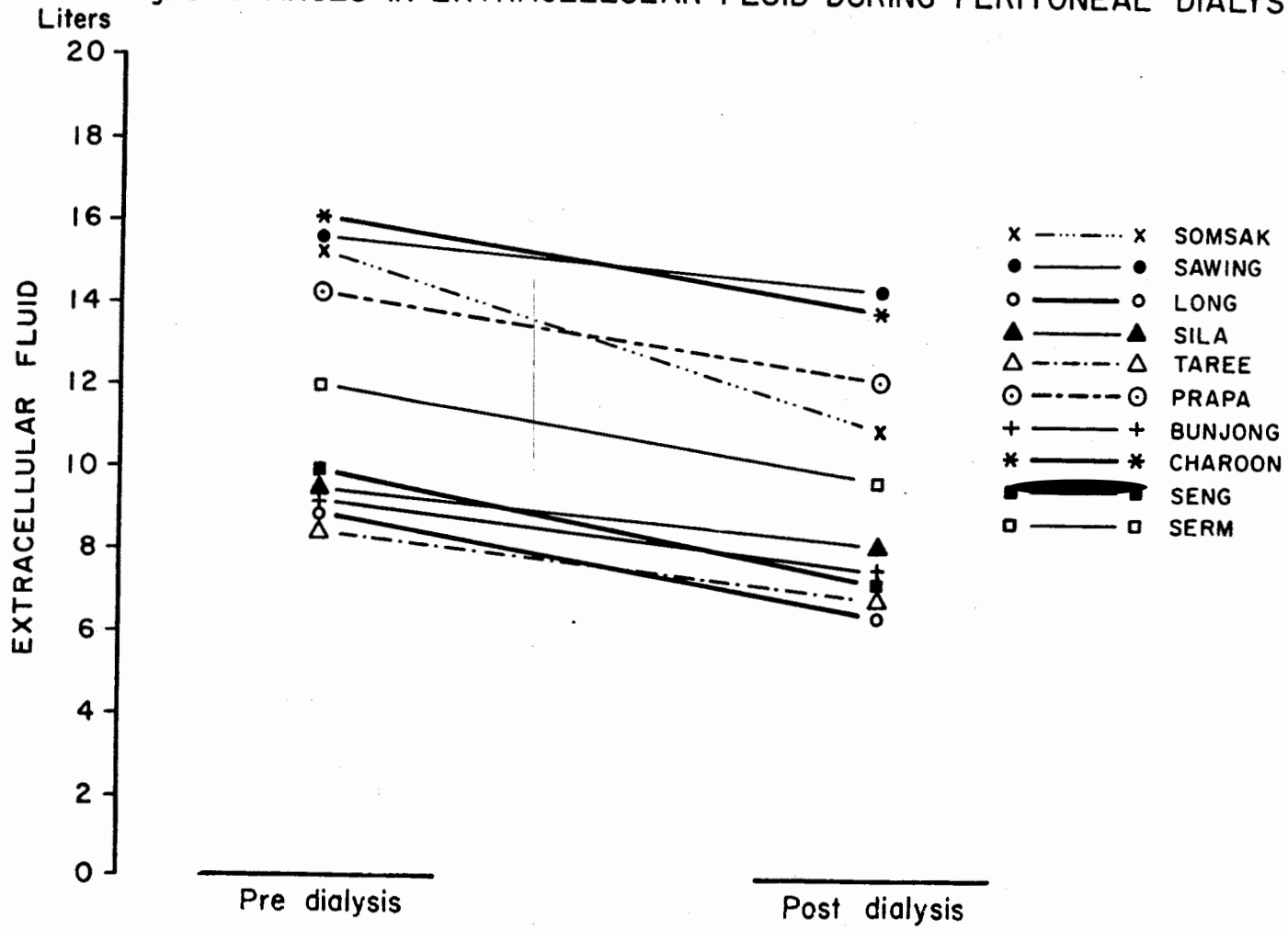
Fig. 5 CHANGES IN EXTRACELLULAR FLUID DURING PERITONEAL DIALYSIS