

# Dumping Syndrome Studied During Maintenance of Blood Volume \*

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A CONSIDERABLE number of studies have been undertaken on the mechanism of the dumping syndrome. Much useful data have been accumulated and have led to numerous theories of etiology. It is not the purpose of this paper to review or add new theories but rather to add new data to the store of facts. Work by Peddie *et al.*<sup>3</sup> includes a sound review of the most recent ideas in this field and presents newly-obtained supporting data.

It has been observed repeatedly during episodes of "dumping" that the ingested material is diluted in the upper intestine by an outpouring of intestinal fluid. This phenomenon is associated with a drop in blood volume which coincides temporally with the symptoms. As would be expected the fall in blood volume has been considered by some the mechanism that initiates the symptoms. If a sudden decrease in blood volume due to water and electrolyte loss were indeed the cause of symptoms certain corollaries would be expected:

1. Patients who do not have dumping symptoms should not show a decrease in blood volume or at least not as great a decrease as those who have symptoms.

2. If the decrease in blood volume is prevented in a patient who usually has symptoms the syndrome should be prevented.

3. If a decrease in blood volume could be accomplished by removal of water and electrolytes from the blood stream without disturbing the gastro-intestinal tract, symptoms should appear similar to those of clinical "dumping."

At least one study<sup>4</sup> has been undertaken to determine if the blood volume decrease

in those with symptoms was different from those without symptoms. Unfortunately, no statistical difference could be shown between the volume changes in their two groups. On the other hand, data from Peddie *et al.*<sup>3</sup> show statistical differences in their two groups. No reports have been found of acute dehydration of the blood stream such as might be obtained by artificial kidney dialysis with hypertonic solution. The dangers to the subjects and the mechanical difficulties for the investigator would seem to make this approach impractical at present. The remaining corollary is within the realm of experimental verification. The experiments presented here show the outcome of such a study.

## Experimental Method

A dilution method using radioactive iodinated serum albumin (RISA) was chosen for measuring plasma volume. A single injection 24 hours before the onset of the experiment according to the method of Abrams *et al.*<sup>1</sup> was selected after a conference with one of the authors.<sup>2</sup> In order to evaluate this method five patients, who had been admitted for hernia repair but were otherwise healthy, were enlisted. Each of these men received an injection of RISA about 8 a.m. of the first day and had a 10-minute blood sample drawn. From the evening of the first day (10 p.m.) to the completion of the studies they fasted. On the morning of the second day, starting at 8 a.m., serial samples of blood were drawn. RISA dilution was determined by radiation counts on the plasma. The plasma volume

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TABLE 1.

Sub- ject	Calculated Plasma Volume (L.)						St. Dev. (cc.)	Total Span (cc.)
	Hours After Injection							
	23.5	24.0	24.5	25.0	25.5	26.5		
A	2.92	3.11	3.01	2.96	3.03	3.04	63	190
B	2.92	3.08	3.04	3.00	3.02	3.05	56	160
C	2.72	2.75	2.75	2.72	2.81	2.69	41	120
D	2.62	2.60	2.61	2.77	2.66	2.67	63	170
E	3.10	3.00	3.06	3.11	3.11	3.24	72	240

was calculated from the 10-minute sample of the first day. The first sample of the second day was assumed to represent the same plasma volume and subsequent plasma volumes were calculated on the basis of the change in radioactivity from this sample.

Table 1 shows the variation seen in serial samples with the standard deviation for each subject. It is to be noted that

there was no progressive change with time noted over the three hour period studied indicating that the biologic decay curve for RISA after 24 hours has a slope sufficiently near zero to be so considered for our purpose.

Each of the postgastrectomy patients was studied during two episodes of induced dumping symptoms. The patient was given an injection of RISA about 8 a.m. on the morning before the study. He fasted overnight and on the morning of the study was given 100 Gm. of glucose in 100 cc. water to initiate the syndrome. Plasma volume was measured just before and at intervals for three hours after the ingestion of the glucose. One week after the first study, the patient was again submitted to induced symptoms and the measurements repeated. The second study on each patient was

TABLE 2. J. I. (April 24)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
124/80	80	49.5	2,210	8:35	
96/64	80			8:40	
116/74	80	49.2	2,200	8:45	
		Test Meal		8:50	
100/60	80			8:55	
		52.0	2,120	9:00	
90/58	96			9:05	
		54.6	1,960	9:10	
80/56	104			9:15	
		57.0	1,860	9:20	
80/56	124			9:25	Slight dizziness
		52.6	1,900	9:30	
78/52	122			9:35	Loose stool
		53.5	2,040	9:40	
86/58	100			9:45	Dizziness gone
		50.5	2,160	9:50	
98/50	92			10:00	
78/54	92	49.5	2,320	10:10	
100/60	90	48.5	2,290	10:30	
98/60	88	48.0	2,230	10:50	
92/60	88	48.5	2,350	11:20	
108/62	84	48.5	2,310	11:50	

modified, however, by giving an intravenous infusion of 1,000 cc. of isotonic saline starting at the time of the test meal in order to maintain the plasma volume at pretest or higher levels.

**Results**

Tables 2-11 give the experimental data. For visual reference a graph is supplied for each patient giving his plasma volume response from the two studies on the same axis. These plots are made from points interpolated from the tabulated measurements which tends to flatten the curves but also decreases the variance of each point. Plasma volume rather than blood volume was chosen for these graphs since blood volume would introduce the additional error in the hematocrit measurement and since the plasma volume rather than the red cell mass is the variable factor. The

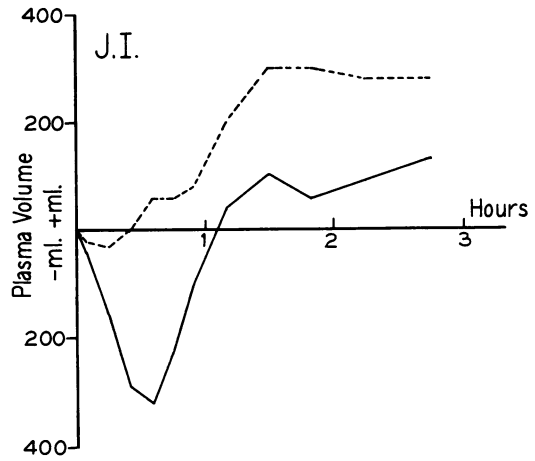


FIG. 1. Solid line—control study; broken line—during infusion.

solid line on each graph represents the initial study; the broken line depicts the second.

TABLE 3. J. I. (May 1)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
106/72	80	51.2	2,030	8:20	
106/72	84			8:25	
		50.5	2,040	8:29	
		Test Meal—I. V. Started		8:30	
104/70	84			8:35	
		50.9	2,000	8:40	
86/68	84	50.8	2,020	8:45	
				8:50	
106/70	84			8:55	
		51.9	2,050	9:00	
94/68	84			9:05	Urge to defecate
		I. V. Complete (1,000 cc. saline)		9:10	
		50.2	2,160	9:11	
94/60	88			9:15	
		51.7	2,050	9:20	Loose stool
90/60	90	49.5	2,180	9:25	
				9:30	
130/60	84			9:40	
		50.2	2,310	9:50	
112/66	84	45.3	2,360	10:10	
104/58	76	44.9	2,310	10:30	
108/60	80	45.4	2,340	11:00	
120/68	80	44.6	2,310	11:30	

TABLE 4. G. E. (June 11)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
112/64	76	47.9	2,840	8:50 8:55	
108/64	76	43.6	3,000	8:59	
106/74	84	Test Meal		9:00 9:05	Belching 1+
		45.4	3,070	9:10	
88/58	86	45.4	2,960	9:15 9:20	Slight belching Slight warmth
100/60	96	47.5	2,830	9:25 9:30	Warmth gone; fullness and nausea 2+ Belching (bitter)
92/64	92			9:35	2+ fullness, weakness and nausea
		47.9	2,760	9:40	Weaker, pain in stomach
96/72	100	48.2	2,770	9:45 9:50	Belching less; weakness gone Symptoms about same
90/70	92	47.8	2,750	9:55 10:00	Pain gone; symptoms improving
96/72	100			10:05	Rare episode nausea and belching
94/60	88	47.0	2,890	10:20	Still occasional belching
90/68	96	45.5	2,970	10:40	Still belching
90/62	92	45.4	2,990	11:00	Rare belching
90/68	80	41.4	3,240	11:30	
86/58	92	41.5	3,300	12:00	Still rare belching

TABLE 5. G. E. (June 18)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
68/40	84	44.0	2,840	9:05	
70/40	84	46.5	2,860	9:10	
68/40	84	42.5	2,900	9:15	
		Test Meal—I. V. Started		9:20	
86/50	84			9:25	Nauseated, belching
		42.7	2,810	9:30	
98/60	80	44.7	2,690	9:35 9:40	Nausea and belching continue
100/66	88	46.1	2,670	9:45 9:50	Nausea and belching almost gone Belching off and on; nausea gone
100/62	92			9:55	
		45.5	2,760	10:00	Belching off and on
98/64	92	43.9	2,820	10:05 10:10	
100/66	88			10:15	Rare belching only symptom
	I. V. Complete (1,000 cc. saline)			10:20	
		42.2	3,030	10:21	

TABLE 5. G. E. (June 18)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
100/66	88			10:25	Very rare belching
98/66	92	43.2	2,900	10:40	
96/58	92		3,080	11:00	
88/44	88	37.8	3,050	11:20	
70/30	88	40.3	3,220	11:50	
62/30	76	40.3	3,370	12:20	

TABLE 6. A. P. (June 12)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
100/70	60	41.1	3,210	8:30	
88/60	60	37.8	3,340	8:40	
90/60	60	39.1	3,340	8:45	
96/70	68	Test Meal		8:50	
				8:55	
96/50	76	41.0	3,320	9:00	
		41.4	3,240	9:05	
				9:10	
96/58	76			9:15	Slight belching
		39.6	3,020	9:20	
80/54	88			9:25	
90/56	96	43.7	2,960	9:30	Slight fullness Belching gone
		43.5	3,020	9:35	
				3,020	9:40
80/52	96			9:45	Fullness less Fullness gone
		43.4	2,890	9:50	
84/56	96			9:55	
78/52	96	43.6	2,910	10:10	Watery bowel movement
84/60	96	42.2	3,150	10:30	
80/52	96	40.6	3,130	10:50	
70/54	92		3,280	11:20	Watery bowel movement
68/50	88	39.4	3,350	11:50	

TABLE 7. A. P. (June 19)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms	
76/50	68	38.4	3,210	8:50		
78/50	68	38.0	3,110	9:00		
90/74	72	38.8	3,140	9:05		
		Test Meal—I. V. Started			9:05	
					9:15	Belching 1+, fullness 1+

TABLE 7. A. P. (June 19)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
92/58	76	37.6	3,140	9:20	Still belching 1+, fullness going
		39.1	3,130	9:25	
				9:30	
88/52	76	38.4	3,060	9:35	Belching and fullness gone
100/48	76			9:40	
				9:45	
90/52	80	39.0	3,120	9:50	
		39.4	3,040	9:55	
				10:00	
100/58	80			10:05	I. V. Complete (1,000 cc. saline)
				10:10	
		38.5	3,210	10:11	
78/50	80			10:15	Dry mouth 1+, watery bowel movement
90/52	84	38.4	3,240	10:30	
88/58	80	36.5	3,290	10:50	
78/50	80	35.7	3,380	11:10	Watery bowel movement
82/52	80	37.0	3,340	11:40	
				11:55	
80/58	80	36.9	3,320	12:10	

TABLE 8. O. C. (September 27)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
146/88	68			8:25	
142/84	68			8:30	
		48.0	3,360	8:35	
144/88	68	45.4	3,310	8:40	Nausea, belching, warmth start 2+
		47.0	3,320	8:45	
		Test Meal		8:50	
148/92	70			8:55	Nausea, belching, warmth gone Heaviness in stomach
154/96	120	47.9	3,110	9:00	
				9:03	Nausea and warmth
				9:06	Emesis 50 cc., bile stained Warmth gone; nausea less Emesis 250 cc., bile stained; nausea gone
		49.5	3,010	9:10	
				9:12	
160/102	120			9:15	
154/98	120	50.0	2,930	9:20	
				9:25	
152-98	116	49.3	3,090	9:30	Asymptomatic
		49.0	3,240	9:35	
				9:40	
154/102	112			9:45	
		49.5	3,180	9:50	
154/100	116			9:55	

TABLE 8. O. C. (September 27)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
142/90	96	48.2	3,240	10:10	
138/88	90	48.5	3,220	10:30	
138/90	88	47.5	3,290	10:50	
132/96	72	48.3	3,330	11:20	
		47.5	3,410	11:50	

TABLE 9. O. C. (October 4)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
134/84	104			8:35	Needle inserted in preparation-subject developed weakness, sweating, nausea
124/86	104	47.8	3,460	8:40	Sweating and dizziness
102/68	60			8:48	Sweating and dizziness less
112/78	72	46.2	3,530	8:55	
112/72	80	45.5	3,630	9:05	Asymptomatic
	Test Meal—I. V. Started			9:10	
128/80	88			9:15	
		44.4	3,710	9:20	Nausea, rapidly increasing to 4+; emesis 100 cc., bile stained
130/88	88			9:25	Alternating warmth and chill
		47.0	3,550	9:30	Weakness; stomach ache; nausea 2+
130/80	100			9:35	Symptoms continue; nausea less
		45.4	3,710	9:40	
120/78	112			9:45	About same; weakness 3+
	I. V. Complete (1,000 cc. saline)			9:50	Nausea and stomach ache gone
		44.5	3,840	9:51	Weakness less
130/84	104			9:55	
		44.1	3,950	10:00	Stomach ache gone; weakness 2+; dizzy 1+; emesis 150 cc., bile stained
134/80	108			10:05	All symptoms gone
		44.7	3,870	10:10	
128/72	108	44.4	3,960	10:30	
118/78	108	43.0	4,020	10:50	
102/74	112	42.2	4,060	11:10	
124/70	84	42.7	3,960	11:40	
		43.0	4,120	12:10	

### Case Reports

**Case 1, J. I.** This 66-year-old white man had a total gastrectomy and esophagojejunostomy for a carcinoma of the stomach. His operation was three months prior to this study. During the first

test he had mild symptoms which were absent during the second study when he had 1,000 cc. of saline over 40 minutes. This loss of symptoms appears to have been associated with the maintenance of the plasma volume (Fig. 1).

TABLE 10. R. M. (February 27)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms
100/68	64	42.1	3,150	8:30 8:35	
100/66	60			8:39	
	Test Meal—I. V. Started			8:40	
116/72	84			8:45	Belching started and stopped
		43.5	3,090	8:50	
	I. V. Complete (250 cc. saline)			8:51	
112/64	90			8:55	
			3,020	9:00	
110/62	104	45.5	3,060	9:05 9:10	Warmth and nausea
108/74	104			9:15	Warmth and nausea less
		44.6	3,050	9:20	
112/70	100			9:25	Warmth and nausea gone
		45.8	3,050	9:30	
104/68	100	43.8	3,140	9:35 9:40	
108/70	100			9:45	
110/70	92	43.1	3,220	10:00	
124/68	90	42.7	3,330	10:20	
106/74	84	43.7	3,160	10:40	
108/70	84	44.7	3,060	11:10	
102/64	72	43.3	3,080	11:40	

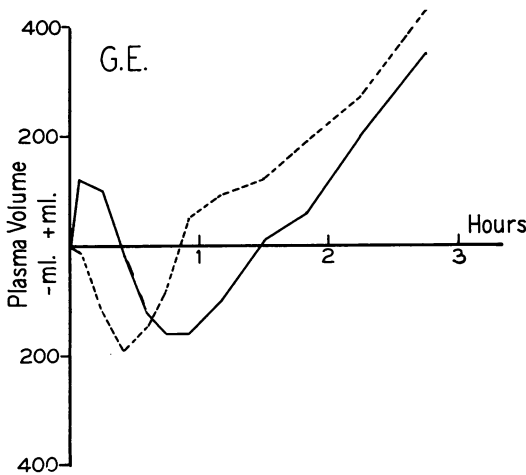


FIGURE 2.

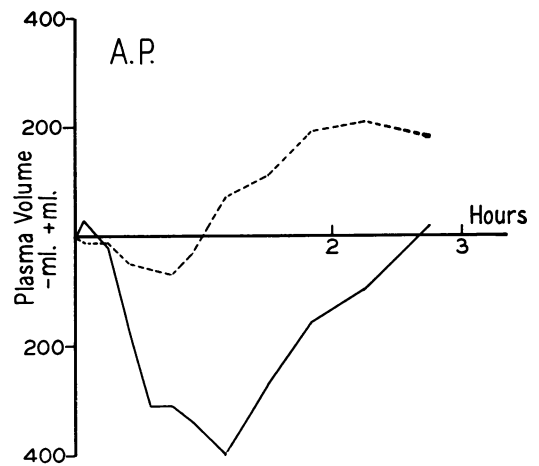


FIGURE 3.



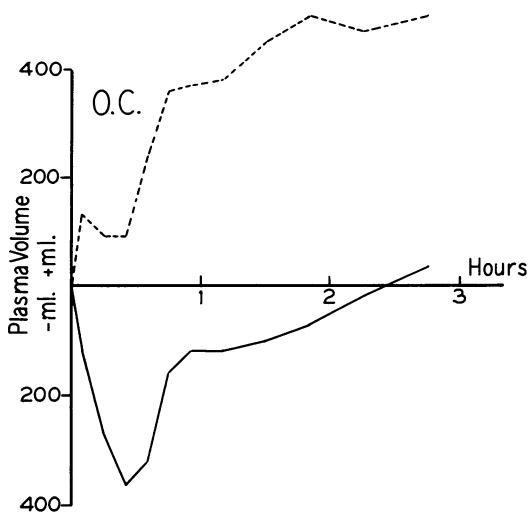


FIGURE 4.

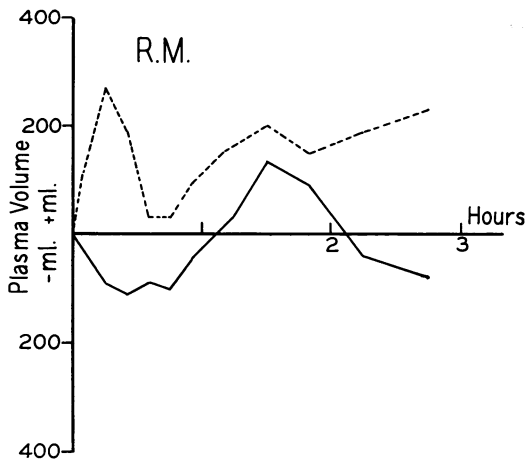


FIGURE 5.

TABLE 11. R. M. (March 6)

Blood Pressure	Pulse	Hematocrit	Plasma Volume	Time	Symptoms	
104/68	68			8:20		
104/68	64			8:25		
		44.0	3,090	8:29		
		Test Meal—I. V. Started			8:30	
108/80	72			8:35	Belching	
		41.5	3,320	8:40	Belching gone	
130/62	80			8:45		
	I. V. Complete (1,000 cc. saline)			8:50		
		41.2	3,390	8:51		
112/68	88			8:55		
		45.8	3,170	9:00		
132/72	100			9:05	Slight nausea	
		46.0	3,060	9:10		
136/68	92			9:15	Slight nausea and warmth	
		44.7	3,170	9:20	Warmth and nausea	
128/70	92			9:25		
		44.0	3,180	9:30		
122/70	96			9:35		
			3,340	9:50		
104/76	92	42.1	3,240	10:10		
104/78	80	41.4	3,230	10:30		
94/68	80	41.7	3,340	11:10		
102/70	80	42.0	3,310	11:30		

**Case 2, G. E.** This 55-year-old white man had a subtotal gastrectomy and a Bilroth II type anastomosis for massive gastro-intestinal bleeding. He was studied five months after operation. During his first test he had rather prominent symptoms. They were absent during the second test except for nausea and belching (probably not truly part of the dumping syndrome). Despite symptomatic improvement the saline was given over 60 minutes and failed to prevent a fall in plasma volume (Fig. 2). The plasma volume drop was in fact almost identical in degree on the two occasions.

**Case 3, A. P.** This 66-year-old white man had an extensive but subtotal gastric resection for carcinoma of the stomach with an anterior gastrojejunostomy. He was studied two months after operation. This patient had a 60-minute infusion of saline during his second test which greatly modified his plasma volume drop but failed to block it entirely (Fig. 3). His symptoms were not modified in any way.

**Case 4, O. C.** This 29-year-old Negro man had a subtotal gastric resection with posterior gastroenterostomy for massive gastro-intestinal bleeding 2½ months before his study. This patient showed pronounced symptoms during his first study and the most marked plasma volume drop seen in this series. During his second test the plasma volume was completely maintained yet his symptoms were essentially the same (Fig. 4). While the needles were being inserted for the second test the patient spontaneously developed typical symptoms. He even appears to have had a decrease in plasma volume (Table 8). After the test meal he again developed symptoms.

**Case 5, R. M.** This 51-year-old white man had a subtotal gastrectomy and Bilroth II type anastomosis three months prior to this study. In this case the patient had 250 cc. saline on his first test and 1,000 cc. saline during the second. As is seen his plasma volume was maintained in the second test but not in the first (Fig. 5). The symptoms were unchanged, however, by this support.

### Discussion

The number of cases studied is too small and the results too varied to derive a com-

prehensive theory of dumping mechanisms. It has been shown that the syndrome can take place even though there is no decrease in plasma or blood volume. The blood volume theory must then be incomplete and though there would certainly seem to be a correlation it can not be considered the whole explanation of symptoms. The cases presented here should serve as a source of further speculation and as a stimulus to further studies.

### Summary

1. An experiment has been designed to test a necessary corollary of the "blood volume" theory of "dumping" symptoms.
2. Five patients were studied with intravenous saline used to maintain their plasma volume during dumping.
3. It has been shown that dumping may occur even though there is no decrease in plasma volume. Drops in volume can not be considered the only mechanism for inducing dumping symptoms and may not be more than a coincidental response.

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