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Blood cellular and biochemical changes after extracorporeal shock wave lithotripsy

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Summary. The present study deals with blood cell behaviour and related hematochemical changes occurring in man after exposure to extracorporeal shock wave lithotripsy (ESWL). The following parameters have been investigated, before and after treatment, in a longitudinal study carried out on 58 patients of our Center: RBC count, Ht, Blood Hb, Plasma Hb, autohemolysis after 72 hours, bilirubinemia, WBC count, platelet count, in vitro platelet aggregation, beta-TG, sideremia and urinary post-exposure transferrin concentration. After exposure to ESWL, with pulse numbers ranging from 350 to 3,000, 18–20 KV, direct and indirect evidences of hemolysis have been found when number of SW exceeded 1,000. The hemolysis rate in different models of in vitro exposure to ESWL of blood samples was also investigated. Increase of WBC count, and changes of the platelet in vitro aggregation patterns were also observed. Changes in sideremia values have been related to urinary loss of transferrin.

Key words: ESWL – Urinary calculi – Hematological parameters – Hematochemical parameters – Hemolysis

Little is known about changes in blood cells and related hematochemical parameters occurring in man after extracorporeal shock wave lithotripsy (ESWL). After in vitro shock wave exposure of blood samples, a significant hemolysis has been reported [2], whereas after exposure of lymphocyte suspensions no change occurred either in mitogenic stimulation with phytohemagglutinin or in mixed lymphocyte cultures [2]. Although 6 years of laboratory investigation have confirmed the safety of ESWL [1, 3, 4, 6–8], the high volume of blood flowing through the kidney during exposure may lead to some subclinical involvement of blood cells.

The present investigation dealt with a longitudinal study on 58 patients treated for upper tract urinary calculi.

The following parameters were analyzed, before and after treatment with different numbers of shock waves: red blood cell (RBC) count, haematocrit value (Ht), blood hemoglobin concentration (BHb), plasma hemoglobin concentration (PHb), autohemolysis after 72 hours of incubation, bilirubinemia (Bil), white blood cell (WBC) and platelet (Pl) count, platelet in vitro aggregation (PlAg), Beta-thromboglobulin plasma levels (Beta-TG), sideremia (Sid) and urinary post-exposure transferrin concentration. Moreover, in vitro experiments have been designed to discriminate between mechanical effects of the shock waves on erythrocytes and possible effects on erythrocyte membranes of the induced currents, generated by the electrical discharge and transmitted through the soft tissues.

Material and methods

In vivo experiments

58 patients, mean age 45.3 years, ranging from 28 to 62 years, were submitted to ESWL with a HM3 Dornier apparatus, at 18–20 KV and pulse numbers ranging from 350 to 3,000.

Anaesthesia was induced after usual premedication, with Succinylcholine 1 mg/kg, Sodium Thiopental 5 mg/kg and Pancuronii bromidium 0.6 mg/kg, and maintained with isoflurane and 60-40% NO and O.

To determine RBC, Ht, BHb, PHb, WBC, Pl, PlAg and Beta-TG, venous blood samples were collected before ESWL (after anaesthetic administration) and after ESWL (during anaesthesia); to determine Sid and Bil, post-exposure samples were collected 24 hours after treatment. Urinary transferrin concentrations were measured in urines collected during the first 24 hours. All the tests were performed by the usual laboratory methods. The autohemolysis test was carried out in citrated blood samples collected before and after treatment and stored in polypropylene tubes for 72 hours at 37°C; then plasma Hb was measured. Urinary transferrin concentration was determined by immunonephelometry.

In vitro experiments

Venous blood samples of 20 ml, collected from healthy volunteers and citrated in a 1:10 vol/vol ratio were introduced in dialysis tubes, whoch were positioned in cylindrical containers of 25 × 8 cm, with different conducibility (polypropylene or metal), filled with buffered

Table 1. Hematological and hematochemical parameters, before and after ESWL, with different numbers of shock waves (see text)

Shock waves	Red blood cell count ($10^3/\mu l$)		Hematocrit (%)		Blood Hb (g/dl)		Plasma Hb (mg/dl)		Autohemolysis after 72 h (plasma Hb mg/dl)		Indirect bilirubinaemia (mg/dl)	
	before	after	before	after	before	after	before	after	before	after	before	after
< 1,000	4,860 ± 480	4,810[e] ± 480	44.5 ± 4.7	43.2[e] ± 5.1	14.4 ± 1.7	13.9[a] ± 1.9	4.4 ± 1.5	6.3[e] ± 4.0	25.5 ± 4.1	34.6[e] ± 7.2	0.60 ± 0.21	0.70[e] ± 0.32
1,000–2,000	4,990 ± 570	4,720[a] ± 550	43.8 ± 4.4	41.3[a] ± 4.1	14.7 ± 1.6	13.8[b] ± 1.4	4.8 ± 4.0	22.5[c] ± 10.2	30.0 ± 7.8	51.5[b] ± 14.5	0.61 ± 0.33	0.92[c] ± 0.65
> 2,000	5,210 ± 570	4,930[b] ± 650	44.8 ± 3.9	42.2[c] ± 4.2	14.1 ± 1.6	13.2[c] ± 1.4	7.0 ± 5.3	34.8[d] ± 15.1	40.1 ± 10.3	99.5[c] ± 30.5	0.68 ± 0.38	1.00[d] ± 0.70

Values are given as mean ± SD

Significance of the before/after differences: [a]$P<0.05$; [b]$P<0.03$; [c]$P<0.01$; [d]$P<0.001$; [e]not significant (Student's t-test)

Table 2. White blood cell count, platelet count and aggregation parameters, before and after ESWL, with different numbers of shock waves (see text)

Shock waves	White blood cell (/μl)		Platelets ($10^3/\mu l$)		Platelet maximum aggregation (collagen)	
	before	after	before	after	before	after
< 1,000	7,283 ± 1,631	8,556[c] ± 2,662	257 ± 47.5	242[c] ± 62.2	34.8 ± 24.4	35.0[c] ± 30.5
1,000–2,000	7,003 ± 2,287	9,084[b] ± 3,307	298 ± 84.9	280[c] ± 86.7	31.2 ± 20.2	64.2[a] ± 29.1
> 2,000	7,295 ± 2,901	9,038[b] ± 2,613	273 ± 10.8	244[c] ± 10.1	38.8 ± 33.4	78.9[b] ± 30.7

Values are given as mean + SD

Significance of the before/after differences: [a]$P<0.02$; [b]$P<0.005$; [c]not significant (Student's t-test)

Table 3. Sideraemia and urinary transferrin concentration, before and after right and respectively left ESWL, with different numbers of shock waves (see text)

Shock waves	Sideraemia (μg/dl)				Urinary transferrin (mg/die)	
	right treatment		left treatment		right treatment	left treatment
	before	after	before	after		
< 1,000	85 ± 33.2	82[c] ± 25.5	86 ± 31.3	81[c] ± 20.7	16 ± 4.7	18 ± 12.9
1,000–2,000	82 ± 26.1	59[a] ± 34.7	74 ± 23.4	76[c] ± 21.2	62 ± 26.0	47 ± 19.6
> 2,000	84 ± 25.5	52[b] ± 27.2	76 ± 22.5	68[c] ± 24.9	114 ± 50.0	120 ± 70.0

Values are given as mean ± SD

Significance of the before/after differences: [a]$P<0.05$; [b]$P<0.01$; [c] not significant (Student's t-test)

Tyrode solution, pH 7.4. Two metal markers at the ends of the dialysis tubes allowed to place, under X-ray control, the blood samples exactly in the second focus of the apparatus. From 2 to 30 shock waves were then applied and plasma hemoglobin concentrations were measured after the exposure.

Results

The results of the in vivo experiments are summarized in Tables 1–3. Figure 1 shows the data of the in vitro hemolysis.

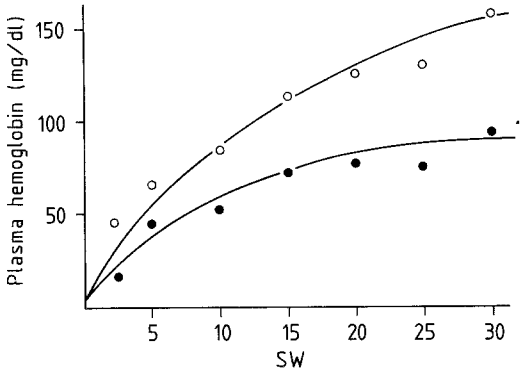

Fig. 1. Hemolysis rates after in vitro exposure to 1–30 shock waves (SW) of citrated blood samples included in metal (○) or polypropylene (●) containers

Discussion

Our results point to the following conclusions:

- A mild but significant hemolysis, as indicated by decreased RBC counts, Ht and BHb, as well as by increased PHb concentrations, occurred when number of shock waves (SW) exceeded 1000; these changes were approximately linear with the number of SW. Indirect evidence of hemolysis was also provided by the increase of indirect bilirubinemia, which was significant between 1,000 and 2,000 SW and highly significant between 2,000 and 3,000 SW (Table 1). Since levels of haptoglobin, which is known to be an acute phase protein, were expected to be affected by ESWL due to general treatment stress, the blood levels of this protein have not been considered as a possible indirect evidence of hemolysis, and therefore have not been evaluated. The in vitro experiments (Fig. 1) have shown that hemolysis in citrated blood samples directly exposed to SW was nearly linear with the number of SW and significantly higher when the blood samples were included in metal containers than in polypropylene ones, suggesting a possible additive effect of induced electrical currents on the erythrocyte membranes. This is in accord with the higher rate of spontaneous hemolysis in post-exposure citrated blood samples stored at 37°C for 72 hours than in the pre-exposure samples (Table 1). Work is in progress in our laboratory about the possible changes of the erythrocyte membrane potentials after in vitro exposure to high energy shock waves.

- Increase of white blood cell count, which was significant even in patients treated with less than 1,000 SW, was immediately detectable at the end of the treatment: this finding points to changes in leukocyte distribution more than to a stimulation of hematopoietic tissues (Table 2).

- Platelet count decrease was not significant; however, it was notewhorty that the in vitro platelet aggregation induced by collagen, but not that induced by ADP, epinephrine or arachidonic acid, was markedly increased in nearly all of the treated patients; this finding could be referred to changes in platelet membrane properties, leading to more favourable exposure of collagen receptors or to activation of transduction mechanisms. Nevertheless, no significant change of post-exposure plasma Beta-thromboglobulin levels was observed (untabulated data).

- Marked urinary transferrin loss was observed during the first 24 hours, strictly dependent on the applied pulse number (Table 3). The extent of this loss allowed us to suppose a corresponding drop of the sideremia values 24 hours after treatment. Alternatively, a decrease of serum iron was to be expected to occurr as an effect of the ESWL general treatment stress. However, surprisingly, a fall in sideremia has been observed, with numbers of SW exceeding 1,000, only when lithotripsy had been performed on the right side (Table 3). As left lithotripsy may include the splenic field in the marginal area of irradiation, our hypothesis is that lack of decrease of sideremia, when the treatment was applied to the left side, may be due to iron release from splenic stores.

These results suggest the need, before ESWL, of a careful evaluation of the hematological status, particularly in subjects affected by hemolytic disorders or by conditions of marked platelet hyperaggregability; however, it must be emphasized that any hematological or hematochemical change of clinical significance was only observed when number of SW exceeded 2,000.

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