Effect of Ultrasound on Major Salivary Glands in Rats: Dynamics of Their Functional State

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The effect of ultrasound irradiation focused onto the gonial angle of the mandibular bone (5-10 sessions) on salivary function of the major salivary glands was examined on laboratory rats. Repeated sonication modified the character of salivary secretion cycle. In addition, it qualitatively changed ionic composition of the saliva.

Key Words: *major salivary glands, ultrasound, rats*

High density of the compact lamina and cancellous matter of the bone tissue can be coped with ultrasound (US) irradiation, which, however, affects the adjacent soft tissues including the glandular tissue of salivary glands (SG), whose normal function is important for the state of organs in the oral cavity [6].

We previously showed that US produces insignificant morphological alterations in the structure of submandibular and sublingual SG in rats [5].

Here we evaluated functional properties of SG after repeated sonication.

MATERIALS AND METHODS

Experiments were carried out on laboratory albino rats under ketamine narcosis (n=55). The mandibular gonial region was shaved and exposed to US. Mineral oil was used as the contact medium. The area of sonic transmitter was 1 cm^2. The pulse mode sonication was performed with an intensity of 0.4 W/cm^2 over 10 min. After 10 sonication sessions, SG function was assessed quantitatively and qualitatively on the postsonication days 5 and 10.

Functional parameters of SG were determined by the latency of appearance of the first saliva drop after injection of 5 mg/kg pilocarpine and by salivation rate (SR).

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The saliva was collected to determine sodium and potassium concentration with an ETs-59 M ionometer (Kvertilab, accuracy for potassium and sodium ions being ±0.3 mM and ±4.0 mM, respectively), total calcium concentration by the murexide method [2], and protein on a HumaLyzer 2000 device with reagents from Huma company.

The animals were killed, the submandibular SG was isolated and dried to constant weight, thereafter the biometrical parameters were assessed [4].

The results were analyzed statistically using Statistica 6.0 software. Significance was assessed using Biostat software [3].

RESULTS

The dynamics of salivation was assessed with pilocarpine stimulation (5 mg/kg). After latent period, two phases of salivation (phases I and II) were observed. The plotted curve (Fig. 1) reflects the phases of the secretory cycle (synthesis, accumulation, and release of the secreta) in the glandular cells [1]. After 5 (Fig. 1, *b*) and 10 (Fig. 1, *c*) days, the shape of salivation plot changed: the latency increased (Table 1), the plot became monophasic (after 5 and especially after 10 days only one peak was seen on the plot).

The previously reported structural alterations in the glandular tissue induced by ultrasonic stimulation are corroborated by functional changes.

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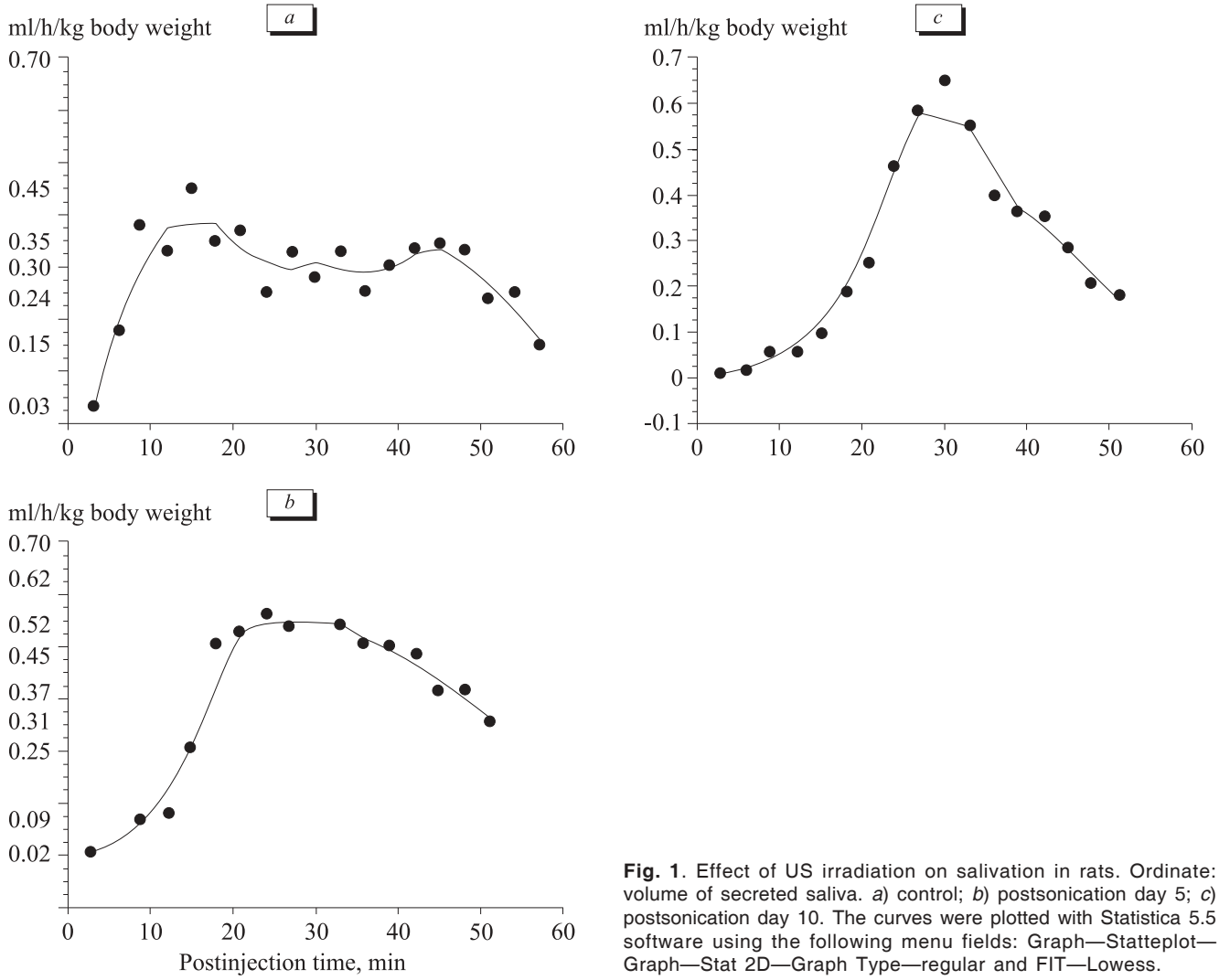

Fig. 1. Effect of US irradiation on salivation in rats. Ordinate: volume of secreted saliva. *a*) control; *b*) postsonication day 5; *c*) postsonication day 10. The curves were plotted with Statistica 5.5 software using the following menu fields: Graph—Statteplot—Graph—Stat 2D—Graph Type—regular and FIT—Lowess.

Latency persistently increased and on postsonication day 10 it attained 169% of the control value ($p<0.05$, Table 1). In contrast, SR did not increase significantly and on day 5 attained only 8.2±2.3 ml/h/kg (the control value was 4.4±0.7 ml/h/kg), which can be explained by considerable variation of the data (Table 1).

Biometrical comparison of real and "theoretical" values of the weight of submandibular SG [4] revealed no significant deviation from the norm, the control data and those obtained on postsonication days 5, 10, and 20 being 45±8, 52±4, 44±4, and 45±2 mg ($p<0.05$, Fig. 2).

The most pronounced changes were found in saliva composition. Potassium concentration and protein content increased during the entire postsonication period. However, sodium concentration significantly decreased on postsonication day 10. US had no effect on calcium concentration.

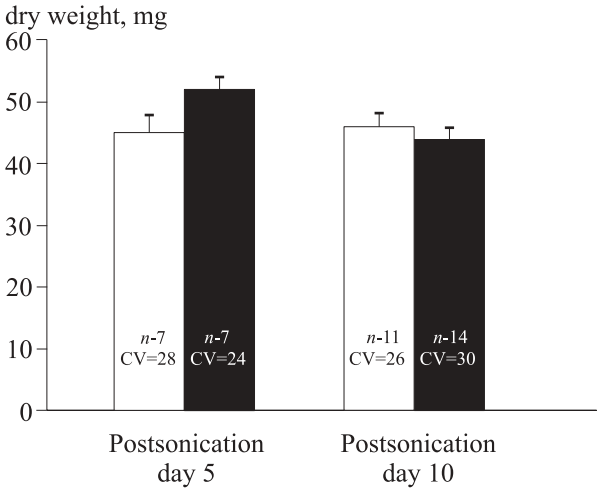

Fig. 2. Effect of US irradiation of gonial angle of mandibular bone on the weight of submandibular SG in rats. Open bars: the calculated (theoretical) weight of submandibular SG. Closed bars, the experimental values of the weight of submandibular SG. *n*, the number of experiments; *CV*, coefficient of variation.

TABLE 1. Effect of US Stimulation of Gonial Angle of Mandibular Bone on Functional Indices of Total Salivation in Rats

Postsonication day		Functional indices		Saliva composition			
		latency	SR (ml/h/kg)	microelements, M			protein, g/liter
				Na^+	K^+	Ca^{2+}	
Control	*M*	8.4	4.42	6.2	41	3.2	1.9
	SEM	0.7	0.70	0.5	1	0.25	0.2
	CV	30	52	26	11	26	32
	n	11	11	11	11	11	11
Day 5	*M*	11.0	8.2	7.7	66	3.1	7.3
	SEM	1.8	2.3	2.3	8	0.8	1.3
	CV	44	72	78	32	59	48
	n	7	7	7	7	7	7
	p	0.05	>0.05	>0.05	<0.01	>0.05	<0.01
Day 10	*M*	14.2	6.5	3.4	63	3.6	5.7
	SEM	2.0	1.1	0.3	3	0.5	1.4
	CV	37	46	26	34	34	66
	n	7	7	7	7	7	7
	p	<0.01	>0.05	<0.01	<0.01	>0.05	<0.01

Note. M, arithmetic mean; *SEM*, standard error of the mean; *CV*, coefficient of variation; *n*, number of experiments; *p*, significance by Student's *t*-test.

Overall, minimum structural changes were accompanied by significant functional shifts: the increase of K^+ concentration in saliva was paralleled by a decrease in Na^+ concentration, which attests to acute damage to SG cells.

Therefore, repeated ultrasonic stimulation of SG area suggested as an "osteoplastic" procedure induces both quantitative and qualitative changes in saliva composition and in salivation. Our data showed that further studies are necessary to clarify the consequences of US stimulation of the tissues in oral cavity.

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