THE BONE ELECTRODE: EFFECTS ON MARROW CELLS IN VITRO

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For the most part, electrical stimulation of bone growth and fracture healing has involved the direct application of current via implanted metal electrodes of various compositions. Since the mechanism of action, the efficiency and the safety of the bone stimulation procedure may be related to the electrode composition, we studied the effect of DC current electrodes on the distribution and viability of bone marrow cells in short term culture. While such a test should be useful in electrode evaluation, it may also provide a clue to the understanding of the complex in vivo osteogenic response.

Aspirations of mature mouse bone marrow were diluted in Dulbecco's culture medium (Flow 1-088D) with 20% fetal calf serum added and placed in special plexiglas chambers for electrical stimulation at 37°C (1). The cathode and anode sides were isolated by agar bridges. Pairs of stainless steel, silver, platinum, gold, titanium or graphite electrodes were studied with 0.5,1,5,10 and 20 microamperes constant current for four hours (electrode surface areas from 16-32 mm^2). After exposure, the cells were allowed to settle on coverslips, fixed, stained with Wright-Giemsa. Differential counts were made of the most prevalent cell groups, as well as lysed cells, in treated cultures and controls without electrodes.

Table I presents a condensed view of the results in terms of averages over all applied currents. The entries are the number of standard deviations above (+) or below (-) control populations for each cell type measured at four hours. The variation of relative population with increasing current (not shown) followed no discernable trend, some cells increasing, while others decreasing or unchanged with each electrode material. From this and the averaged data in Table I, it seems that both cell-specific and electrode-specific effects were operative, resulting in part, in selective lysis.

TABLE I. RELATIVE POPULATION SHIFTS IN MOUSE BONE MARROW CELLS AFTER 4 HRS. OF ELECTRICAL STIMULATION.
Shown is the number of standard deviations above (+) or below (-) control cultures in relative population averaged over 0.5 - 20 μA trials. Neu = neuthrophils, Eos = eosinophils, Lym = lymphocyte group. Ery = erythroid series, Lysed = lysed and severly deformed cells. SS = stainless steel, GR = graphite.

		Neu	Eos	Lym	Ery	Lysed
SS	anode	-1	0	0	0	0
	cathode	-2	0	0	0	+10
Ag	anode	+1	+4	-2	0	+3
	cathode	0	+2	-1	0	0
Pt	anode	-2	+2	0	0	+3
	cathode	-1	+1	0	0	+4
Au	anode	0	0	0	0	0
	cathode	0	+1	0	0	0
Ti	anode	-1	0	+2	0	0
	cathode	-1	0	0	0	0
GR	anode	+1	0	0	0	0
	cathode	+1	+2	-1	0	+3

The data in Table I also indicate that large changes in bone marrow cells might be expected near platinum or silver anodes, and stainless steel, platinum or graphite (carbon) cathodes. Lysed cells, normally about 7% in our preparation, increased to about 34% in the stainless cathode chambers. The most benign cathodes were gold and titanium, followed by silver. It is interesting to note that the five metal cathodes which have been used for bone stimulation tended to depress the neutrophil population and/or increase the eosinophils. Alterations in the erythroid population were observed, but were within the wide control range. Further long-term tests in vivo will be necessary to confirm these findings.

1. J.A. Spadaro, et al, Antimicrob. Ag. Chemother. 6, 637 (1974).

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