The relative contribution of the various multipolar components to the total surface potential was determined in experiments on the isolated heart located in a spherical volume conductor. These contributions were calculated for distances from the electrodes to the center of the cardiac ventricles that corresponded to the placement of standard and thoracic ECG recording electrodes in different age groups. On the basis of these results the optimal model of an equivalent cardiac generator can be chosen for a given electrocardiographic recording system.

KEY WORDS: Equivalent cardiac generator; parameters of the generator; electrocardiographic leads.

The present investigation was carried out for this purpose.

EXPERIMENTAL

Experiments were carried out on the isolated heart of an adult mongrel dog (7 experiments). The isolated heart was perfused with a stabilized donor's circulation. Synchronized recordings were obtained of unipolar electrocardiograms with leads from 266 points, using silver electrodes arranged uniformly on the spherical surface of a volume conductor (physiological saline) surrounding the heart. The winding speed of the recording tape was 500 mm/sec. The curves are presented in numerical form. For this purpose readings were taken of each component of the QRS complex at 15 points 4 msec apart. The signal value at each moment of time was expressed in millivolts.

As a result, data were obtained on the distribution of the potential over a spherical surface at each of 15 moments of the QRS complex. From this distribution the component of the equivalent generator and their contributions to the surface potential were determined. The method of calculation was described by Plonsey in 1966 [7].

The contribution of the various components of the multipole to the surface potential on the human chest was estimated on the assumption that the contribution of a multipole of the n-th order is inversely proportional to the distance of the recording electrodes from the center of the heart, taken to the (n+1)th
power. It was assumed that the heart of the healthy dog and of the healthy human subject are generators with a similar structure.

The mean-square potential of a spherical surface with radius equal to the distance of the electrodes to the center of the heart was taken as the potential of the thoracic electrode. To calculate these distances, corresponding to precordial electrodes from V1 to V6, the results of an anthropologic investigation of 6960 persons were analyzed (Scientific Report of the Institute of Anthropology, Moscow University, Moscow, 1957-1961).

On the basis of the anthropometric data, transverse sections through the chest at the level of the 4th-5th intercostal space were reconstructed, the coordinates of the center of the cardiac ventricles were then plotted on these sections [3], and the distances from it to the points corresponding to the thoracic electrodes were calculated graphically [2].

RESULTS

The contribution of the dipolar and quadripolar components on the average for the whole duration of the QRS interval of the cardiac cycle were practically identical for all seven experiments (the scatter of the data was less than 5%). This small scatter of the values of the contributions obtained shows that the heart of healthy dogs is stable as a generator and differs only slightly in different individuals. The mean results of all the experiments are given diagrammatically in Fig. 1. The relative contribution of the dipolar component of an equivalent multipolar cardiac generator to the total surface potential was evidently 46%, while that of the dipolar and quadripolar components together was 65%. The remaining 35% of the potential was determined by higher multipolar components.

The contributions of the various multipolar components of the same generator to the potential of the thoracic electrodes depended primarily on the distance of these electrodes from the point of application of the generator. To calculate these contributions it was therefore essential to know the distance from the thoracic electrocardiographic electrodes to the center of the heart. These distances are given in Table 1 for persons of three age groups: 7-14, 15-29, and 45-59 years. The data in Table 1 show that the distance actually varies substantially with age and that the distances are shortest for electrodes at the points V1-V3. The results of the calculation of the contribution of dipolar, combined quadripolar and dipolar, and of all multipolar components of a higher order together, for different distances of the recording electrodes from the center of the heart, are given in Fig. 2. Analysis of the curves in Fig. 2 shows that the potential of the