Twelve-lead electrocardiogram obtained by eight leads

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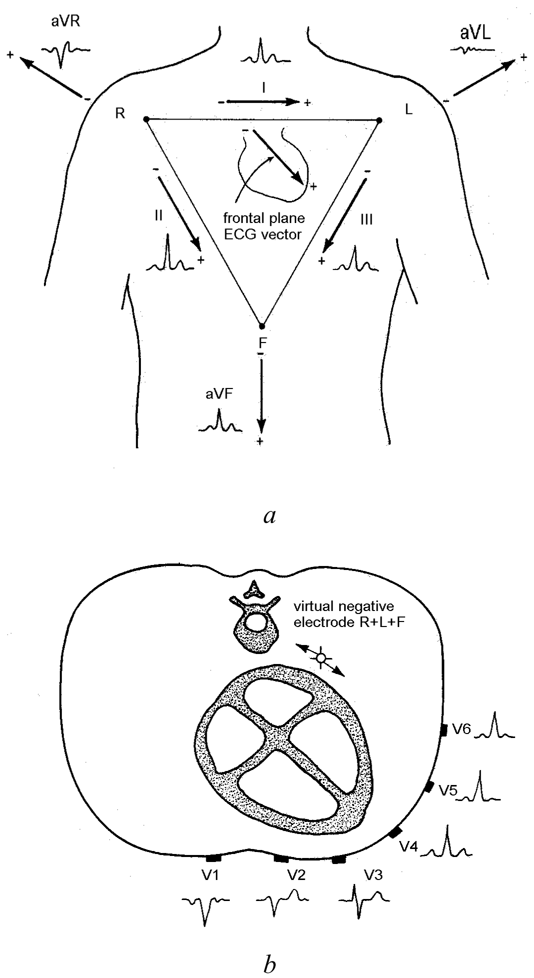
The electrocardiogram is acquired by ten electrodes attached to the patient's body and transformed into 12 leads, recorded in 12 channels. This transformation requires the use of resistive networks, which involves either degrading of the amplifier input impedances and common-mode rejection ratio, or the need of interface buffers to each input lead. Modern computerized electrocardiographs allow avoiding of the resistive networks. A straightforward method for computing the 12-lead data from 8 'primary' leads is presented.

12 стандартни отвеждания получени от 8 канала*. Електрокардиограмата се отвежда от 10 електрода и сигналите се преобразуват в 12 отвеждания, регистрирани в 12 канала. Тази трансформация изисква използването на групи резистори, които или влошават входния импеданс и режекцията на синфазни сигнали на усилвателите, или налагат използването на буфери към всеки електроден извод. Предложен е пряк метод за пресмятане на 12-те сигнала от 8 'първични' отвеждания.*

We have shown the possibility to obtain the twelve standard ECG leads from eight 'primary leads', acquired by appropriate multichannel amplifier [1, 2]. This approach proved very convenient for microprocessor electrocardiographs, as it avoids the use of input buffers with resistor networks for the Goldberger and Wilson terminals. Besides, it reduces memory space (1.5 times) and the number of operational amplifiers in the ECG unit floating circuit. We are routinely applying this method in all electrocardiographs and various other ECG systems developed by us. It is also applicable for storing of 8 channel ECG records in a database and recovering subsequently the standard 12 lead signals [3]. Moreover, this method is the only solution to the task of storing 12-lead signals of a database in an ECG simulator and sending adequate signals to the 10 leads of a standard patient cable. In this case the 12 leads are converted through 8 differences into 9 electrode potentials.

This transformation was only briefly described in the first publication of a microprocessor electrocardiograph and in a subsequent overview on acquisition and recording of ECG signals [1, 2]. The same relates to the reverse transformation, applied in an ECG simulator [3]. As questions on specific properties of this method were often asked, we consider that the underlying principle should be presented in full.



a

b

Fig. 1 (a). Electrode positions and leads for the peripheral leads; (b) Electrode positions and leads for the precordial leads.

The 9 ECG electrodes, attached at the two arms **R** and **L**, the left leg **F** and the six chest locations **(V_1÷V_6)** may yield 8 potential differences, referred to one of the electrodes, **F** in our case. The right leg **N** electrode is the usual common point of the differential amplifiers and does not participate in the transformation. Thus 8 amplifier channels are used, yielding the additional advantage of convenient multiplexing by a single chip.

The commonly accepted designations of electrode positions and leads are shown in Fig. 1a for the peripheral leads and in Fig. 1b for the precordial leads.

The eight potential differences (Fig. 2a), referred to the **F** electrode, designated as primary leads are:

$$R_F = R - F$$

$$L_F = L - F$$

$$C_{i,F} = C_i - F, \quad \text{for} \quad i = 1, 2, \ldots 6$$

The standard 12 leads, I, II, II, aVR, aVL, aVF, V_1-V_6, shown in Fig. 2b, are derived as follows:

$$I = L_F - R_F \equiv L - R$$

$$II = -R_F \equiv F - R$$

$$III = -L_F \equiv F - L$$

$$aVR = R_F - \frac{L_F}{2} \equiv R - \frac{L+F}{2} \equiv \frac{III}{2} - II$$

$$aVL = L_F - \frac{R_F}{2} \equiv L - \frac{R+F}{2} \equiv \frac{II}{2} - III$$

$$aVF = -\frac{R_F + L_F}{2} \equiv F - \frac{R+L}{2} \equiv \frac{II + III}{2}$$

$$V_i = C_{i,F} - \frac{R_F + L_F}{3} \equiv C_i - \frac{R+L+F}{3}$$

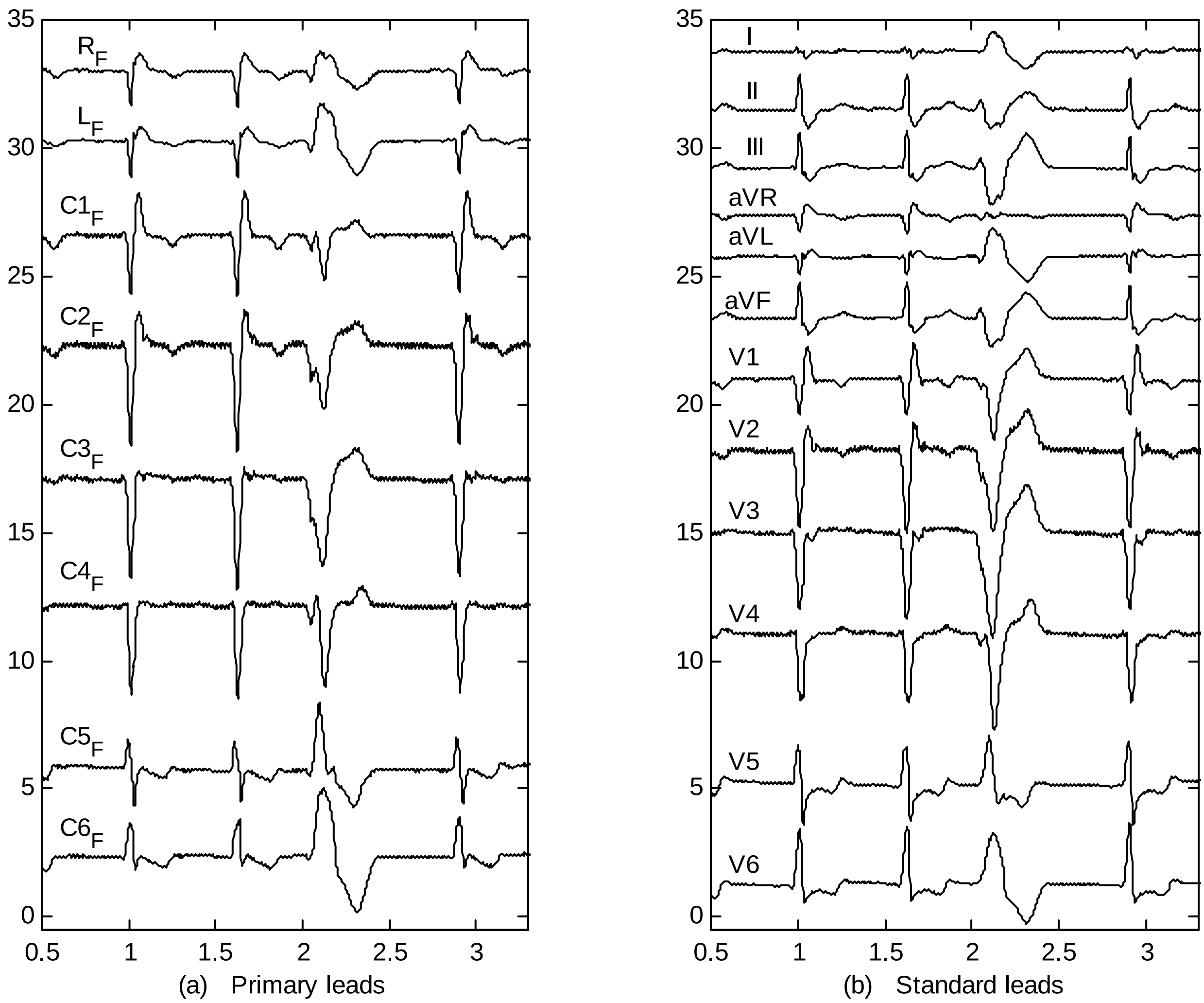


Fig. 2

The reverse transformations are:

$$F = const = 0$$

$$R_F = -II$$

$$L_F = -III$$

$$C_{i,F} = V_i - \frac{II + III}{3}$$

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