

American Clinical Neurophysiology Society

Guideline 6: A Proposal for Standard Montages to Be Used in Clinical EEG¹

Introduction

A great diversity of montages exists among different EEG laboratories, and many of these montages fail to display the EEG adequately or are inordinately complex. Moreover, this diversity impedes interchange of information among electroencephalographers, to the ultimate detriment of patients.

Recognizing the need for improving this aspect of EEG practice, the montages listed in this Guideline are recommended for standard use by clinical laboratories. This proposal should not be construed as an attempt to limit the total number of montages used by any EEG laboratory. Indeed, depending on individual recording circumstances, additional montages may be necessary for an adequate EEG examination and for the solution of particular problems. The proposed montages are intended to constitute a basic minimum, not a maximum, for general-purpose use. If these recommendations are adopted widely, communication among electroencephalographers should be facilitated.

Further, the proposed montages are not designed for special purposes, such as for neonatal EEGs, recording with sphenoidal leads, all-night sleep recordings, or for verification of electrocerebral inactivity.

1. Montage Designations

1.1 The class of montage is designated as follows: longitudinal bipolar (LB), transverse bipolar (TB), or referential (R). (Bipolar derivations are also sometimes called “differential”.)

1.2 The numeral to the left of the point indicates the number of channels. Montages are designed for 16, 18, and 20 channels.

1.3 The numeral 2 or 3 to the right of the point indicates an alternative montage of the same class for a particular size of instrument (e.g., LB-16.2 and LB-16.3 are alternative for LB-16.1). The number of alternatives has been limited to a maximum of three.

2. Recommendations Governing Selection of the Proposed Montages with Explanatory Notes

2.1 The Committee *reaffirms* the statements pertaining to montages set forth previously in the Guidelines of the American Clinical Neurophysiology Society (ACNS) and that are paraphrased as follows:

- (a) that no less than 16 channels of simultaneous recording be used, and that a larger number of channels be encouraged,
- (b) that the full 21 electrode placements of the 10-20 System be used,
- (c) that both bipolar and referential montages be used,

¹ This topic was previously published as Guideline 7.

- (d) that the electrode connections for each channel be clearly indicated at the beginning of each montage,
- (e) that the pattern of electrode connections be made as simple as possible and that montages should be easily comprehended,
- (f) that the electrode connections (bipolar) preferentially should run in straight (unbroken) lines and the interelectrode distances kept equal,
- (g) that tracings from the more anterior electrodes be placed above those from the more posterior electrodes on the recording page, and
- (h) that it is very desirable to have some of the montages comparable for all EEG laboratories.

2.2 The Committee recommends a “left above right” order of derivations, i.e., on the recording page left-sided leads should be placed above right-sided leads for either alternating pairs of derivations or blocks of derivations. This recommendation coincides with the prevailing practice of the vast majority of EEG laboratories in North America and by laboratories in some, but not all, other countries.

2.3A maximum number of electrodes should be represented in each montage, within limitations imposed by the number of recording channels, to ensure adequate coverage of head areas.

2.4 Three classes of montage should be represented in each recording: LB, TB, and R.

2.5 For 16- and 18-channel recording, one montage from each of the three classes will be needed (see Table 1).

2.6 If 20 channels are available, 2 channels of polygraphic variables may be added to the 18-channel bipolar montages, and a reference to Cz in between those to Fz and Pz.

TABLE 1: *Number of montages recommended*

| Number of channels | Longitudinal bipolar | Transverse bipolar | Referential | Total |
|--------------------|----------------------|--------------------|-------------|-------|
| 20 | 1 (3) | 1 (2) | 1 (3) | 3 |
| 18 | 1 (3) | 1 (2) | 1 (3) | 3 |
| 16 | 1 (3) | 1 (3) | 1 (3) | 3 |

(Figures in parentheses refer to the number of alternative montages proposed.)

For adequate mapping of electrical fields, additional montages may need to be devised that include LB and TB chains recorded simultaneously.

In the montages listed for R recording, leads on the mandibular angles may be substituted for the leads on the earlobes if the change is duly noted.

Potential pitfalls in referential recording are numerous, and caution should be exercised if unwanted activity appears in a reference lead. In such instances, another reference should be chosen and the change should be clearly noted in the recording. Common alternative choices of reference include Cz and an average constructed from all electrodes on the head. In average reference recording, the prefrontal electrodes F3 and F4 are often omitted from the average to reduce contamination by eye movement artifact.

2.6 A logical order of arrangement should prevail in each montage and in comparable montages designed for instruments of different sizes.

Recognizing the fact that experienced electroencephalographers differ for valid reasons in their approach to the display of EEG activity, alternative sets of montages have been included in the recommendations. Further details about the principles of montage design and the different preferences by members of this Committee have been published (*Am J EEG Technol*, 17:Nos. 1 and 2, 1977).

In general, the LB.1 and the R.1 series consist of leads grouped in anatomical proximity and extending sequentially across the head from the left to the right. In this system, hemispheric differences are readily appreciated. In the LB.2 and LB.3 series, blocks of homologous derivations are compared (LB.2 extending from the midline sagittal region laterally, LB.3 extending from lateral regions medially). In the R.2 and R.3 series, homologous derivations are juxtaposed in adjacent channels to facilitate comparison of localized regions (R.2 extending from the midline sagittal region laterally and R.3 extending from the lateral regions medially). The alternative montages in the TB series depend, in part, on the extent of polar coverage.

Minor modifications of the recommended montages may be instituted during part of the recording, especially for monitoring other physiologic variables, if the modifications do not infringe upon the principles set forth in these Recommendations.

Longitudinal Bipolar Montages

| <i>Channel No.</i> | <i>LB-18.1</i> | <i>LB-18.2</i> | <i>LB-18.3</i> |
|--------------------|-----------------|-----------------|-----------------|
| 1 | Fp1-F7 | Fz-Cz | Fp1-F7 |
| 2 | F7-T7 (T3) | Cz-Pz | F7-T7 (T3) |
| 3 | T7 (T3)-P7 (T5) | Fp1-F3 | T7 (T3)-P7 (T5) |
| 4 | P7 (T5)-O1 | F3-C3 | P7 (T5)-O1 |
| 5 | Fp1-F3 | C3-P3 | Fp2-F8 |
| 6 | F3-C3 | P3-O1 | F8-T8 (T4) |
| 7 | C3-P3 | Fp2-F4 | T8 (T4)-P8 (T6) |
| 8 | P3-O1 | F4-C4 | P8 (T6)-O2 |
| 9 | Fz-Cz | C4-P4 | Fp1-F3 |
| 10 | Cz-Pz | P4-O2 | F3-C3 |
| 11 | Fp2-F4 | Fp1-F7 | C3-P3 |
| 12 | F4-C4 | F7-T7 (T3) | P3-O1 |
| 13 | C4-P4 | T7 (T3)-P7 (T5) | Fp2-F4 |
| 14 | P4-O2 | P7 (T5)-O1 | F4-C4 |
| 15 | Fp2-F8 | Fp2-F8 | C4-P4 |
| 16 | F8-T8 (T4) | F8-T8 (T4) | P4-O2 |
| 17 | T8 (T4)-P8 (T6) | T8 (T4)-P8 (T6) | Fz-Cz |
| 18 | P8 (T6)-O2 | P8 (T6)-O2 | Cz-Pz |

| <i>Channel No.</i> | <i>LB-16.1</i> | <i>LB-16.2</i> | <i>LB-16.3</i> |
|--------------------|-----------------|-----------------|-----------------|
| 1 | Fp1-F7 | Fp1-F3 | Fp1-F7 |
| 2 | F7-T7 (T3) | F3-C3 | F7-T7 (T3) |
| 3 | T7 (T3)-P7 (T5) | C3-P3 | T7 (T3)-P7 (T5) |
| 4 | P7 (T5)-O1 | P3-O1 | P7 (T5)-O1 |
| 5 | Fp1-F3 | Fp2-F4 | Fp2-F8 |
| 6 | F3-C3 | F4-C4 | F8-T8 (T4) |
| 7 | C3-P3 | C4-P4 | T8 (T4)-P8 (T6) |
| 8 | P3-O1 | P4-O2 | P8 (T6)-O2 |
| 9 | Fp2-F4 | Fp1-F7 | Fp1-F3 |
| 10 | F4-C4 | F7-T7 (T3) | F3-C3 |
| 11 | C4-P4 | T7 (T3)-P7 (T5) | C3-P3 |
| 12 | P4-O2 | P7 (T5)-O1 | P3-O1 |
| 13 | Fp2-F8 | Fp2-F8 | Fp2-F4 |
| 14 | F8-T8 (T4) | F8-T8 (T4) | F4-C4 |
| 15 | T8 (T4)-P8 (T6) | T8 (T4)-P8 (T6) | C4-P4 |
| 16 | P8 (T6)-O2 | P8 (T6)-O2 | P4-O2 |

Transverse Bipolar Montages

| <i>Channel No.</i> | <i>TB-18.1</i> | <i>TB-18.2</i> |
|--------------------|----------------|----------------|
| 1 | F7-Fp1 | Fp1-Fp2 |
| 2 | Fp1-Fp2 | F7-F3 |
| 3 | Fp2-F8 | F3-Fz |
| 4 | F7-F3 | Fz-F4 |
| 5 | F3-Fz | F4-F8 |
| 6 | Fz-F4 | A1-T7 (T3) |
| 7 | F4-F8 | T7 (T3)-C3 |
| 8 | T7 (T3)-C3 | C3-Cz |
| 9 | C3-Cz | Cz-C4 |
| 10 | Cz-C4 | C4-T8 (T4) |
| 11 | C4-T8 (T4) | T8 (T4)-A2 |
| 12 | P7 (T5)-P3 | P7 (T5)-P3 |
| 13 | P3-Pz | P3-Pz |
| 14 | Pz-P4 | Pz-P4 |
| 15 | P4-P8 (T6) | P4-P8 (T6) |
| 16 | P7 (T5)-O1 | O1-O2 |
| 17 | O1-O2 | Fz-Cz |
| 18 | O2-P8 (T6) | Cz-Pz |

| <i>Channel No.</i> | <i>TB-16.1</i> | <i>TB-16.2</i> | <i>TB-16.3</i> |
|--------------------|----------------|----------------|----------------|
| 1 | F7-Fp1 | Fp1-Fp2 | F7-Fp1 |
| 2 | Fp1-Fp2 | F7-F3 | Fp2-F8 |
| 3 | Fp2-F8 | F3-Fz | F7-F3 |
| 4 | F7-F3 | Fz-F4 | F3-Fz |
| 5 | F3-Fz | F4-F8 | Fz-F4 |
| 6 | Fz-F4 | A1-T7 (T3) | F4-F8 |
| 7 | F4-F8 | T7 (T3)-C3 | T7 (T3)-C3 |
| 8 | T7 (T3)-C3 | C3-Cz | C3-Cz |
| 9 | C3-Cz | Cz-C4 | Cz-C4 |
| 10 | Cz-C4 | C4-T8 (T4) | C4-T8 (T4) |
| 11 | C4-T8 (T4) | T8 (T4)-A2 | P7 (T5)-P3 |
| 12 | P7 (T5)-P3 | P7 (T5)-P3 | P3-Pz |
| 13 | P3-Pz | P3-Pz | Pz-P4 |
| 14 | Pz-P4 | Pz-P4 | P4-P8 (T6) |
| 15 | P4-P8 (T6) | P4-P8 (T6) | P7 (T5)-O1 |
| 16 | O1-O2 | O1-O2 | O2-P8 (T6) |

Referential Montages

| <i>Channel No.</i> | <i>R-18.1</i> | <i>R-18.2</i> | <i>R-18.3</i> |
|--------------------|---------------|---------------|---------------|
| 1 | F7-A1 | Fz-A1 | F7-A1 |
| 2 | T7 (T3)-A1 | Pz-A1 | F8-A2 |
| 3 | P7 (T5)-A1 | Fp1-A1 | T7 (T3)-A1 |
| 4 | Fp1-A1 | Fp2-A2 | T8 (T4)-A2 |
| 5 | F3-A1 | F3-A1 | P7 (T5)-A1 |
| 6 | C3-A1 | F4-A2 | P8 (T6)-A2 |
| 7 | P3-A1 | C3-A1 | Fp1-A1 |
| 8 | O1-A1 | C4-A2 | Fp2-A2 |
| 9 | Fz-A1 | P3-A1 | F3-A1 |
| 10 | Pz-A2 | P4-A2 | F4-A2 |
| 11 | Fp2-A2 | O1-A1 | C3-A1 |
| 12 | F4-A2 | O2-A2 | C4-A2 |
| 13 | C4-A2 | F7-A1 | P3-A1 |
| 14 | P4-A2 | F8-A2 | P4-A2 |
| 15 | O2-A2 | T7 (T3)-A1 | O1-A1 |
| 16 | F8-A2 | T8 (T4)-A2 | O2-A2 |
| 17 | T8 (T4)-A2 | P7 (T5)-A1 | Fz-A1 |
| 18 | P8 (T6)-A2 | P8 (T6)-A2 | Pz-A2 |

| <i>Channel No.</i> | <i>R-16.1</i> | <i>R-16.2</i> | <i>R-16.3</i> |
|--------------------|---------------|---------------|---------------|
| 1 | F7-A1 | Fp1-A1 | F7-A1 |
| 2 | T7 (T3)-A1 | Fp2-A2 | F8-A2 |
| 3 | P7 (T5)-A1 | F3-A1 | T7 (T3)-A1 |
| 4 | Fp1-A1 | F4-A2 | T8 (T4)-A2 |
| 5 | F3-A1 | C3-A1 | P7 (T5)-A1 |
| 6 | C3-A1 | C4-A2 | P8 (T6)-A2 |
| 7 | P3-A1 | P3-A1 | Fp1-A1 |
| 8 | O1-A1 | P4-A2 | Fp2-A2 |
| 9 | Fp2-A2 | O1-A1 | F3-A1 |
| 10 | F4-A2 | O2-A2 | F4-A2 |
| 11 | C4-A2 | F7-A1 | C3-A1 |
| 12 | P4-A2 | F8-A2 | C4-A2 |
| 13 | O2-A2 | T7 (T3)-A1 | P3-A1 |
| 14 | F8-A2 | T8 (T4)-A2 | P4-A2 |
| 15 | T8 (T4)-A2 | P7 (T5)-A1 | O1-A1 |
| 16 | P8 (T6)-A2 | P8 (T6)-A2 | O2-A2 |