Diagnosis and discrimination of remote antero- and inferoseptal non-Q wave myocardial infarctions with body surface potential mapping

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BACKGROUND: Previous studies have shown that the diagnosis and localization of previous non-Q wave myocardial infarction (NQMI) is possible by body surface potential mapping (BSPM), but the criteria for the discrimination between antero-septal and inferoseptal middle regions remain to be determined.

METHODS: BSPM using 63 unipolar leads was recorded in 119 patients with previous NQMI (36 to 76 years of age, average 61 years; 85 men). Localization of antero-septal or inferior middle NQMI occurred in 70 cases (44 to 76 years of age, average 61 years, 53 men) by determining early anterior minimum potential with only slight negativity. In these cases, isopotential maps obtained at additional time points were investigated to discriminate between antero-septal and inferoseptal NQMI. The clinical localization was based on the concordance of two of the following tests: wall motion disturbances on echocardiography, coronary angiogram and repolarization changes in the acute-phase electrocardiogram.

RESULTS: Two milliseconds before the appearance of the first anterior minimum, a more accentuated superior negativity indicated antero-septal NQMI (32 of 70 cases), while a more pronounced inferior negativity indicated inferoseptal NQMI (38 of 70 cases). Fisher's exact test showed statistically significant associations between the above BSPM localizations and the clinical localizations ($P < 0.001$). Occlusion or stenosis of the expected infarct-related coronary artery was detected in all patients either as a single lesion or together with other coronary artery lesions.

CONCLUSIONS: The BSPM criteria proposed here are suitable to detect the most frequent NQMI localizations. The narrowing of the infarct-related coronary arteries, the left anterior descending or the posterior descending coronary artery, can be thus differentiated.

Key Words: Body surface potential mapping; Non-Q MI localization; Remote septal infarctions

NON-Q WAVE MYOCARDIAL INFARCTION

The detection of remote non-Q wave myocardial infarction (NQMI) is clinically important because it indicates significant ischemic heart disease. Although in the acute phase the diagnosis is usually straightforward (repolarization changes on the electrocardiogram [ECG] and high necroenzyme levels), the localization of older lesions is more difficult because NQMI in a later phase may not be evident using the standard 12-lead ECG. Wall motion abnormalities may be detected by cardiac ultrasound (transthoracic echocardiography [TTE]) or with invasive

Le diagnostic et la discrimination des infarctus myocardiques antéroseptaux et inféroseptaux incomplets antérieurs par cartographie du potentiel de surface corporelle

HISTORIQUE : Des études passées ont démontré qu'il est possible de diagnostiquer et de localiser un infarctus myocardique incomplet (IMI) antérieur par cartographie du potentiel de surface corporelle (CPSC), mais que les critères pour discriminer les régions centrales antéroseptale et inféroseptale n'ont pas encore été déterminés.

MÉTHODOLOGIE : Au moyen de 63 dérivations unipolaires, les auteurs ont enregistré la CPSC de 119 patients ayant déjà subi un IMI (de 36 à 76 ans, moyenne de 61 ans; 85 hommes). Ils ont pu localiser l'IMI antéroseptal ou inférieur central dans 70 cas (44 à 76 ans, moyenne de 61 ans; 53 hommes) en déterminant le potentiel minimal antérieur précoce avec seulement une légère négativité. Dans ces cas, les auteurs ont examiné les cartes isopotentiellées obtenues à d'autres moments pour discriminer entre l'IMI antéroseptale et l'IMI inféroseptale. Le foyer clinique dépendait de la concordance de deux des tests suivants : perturbations du mouvement des parois à l'échocardiographie, coronarographie et changements de repolarisation à l'électrocardiogramme en phase aiguë.

RÉSULTATS : Deux millisecondes avant l'apparition du premier minimum antérieur, une négativité supérieure plus accentuée indiquait un IMI antéroseptal (32 des 70 cas), tandis qu'une négativité inférieure plus prononcée indiquait un IMI inféroseptal (38 des 70 cas). La méthode exacte de Fisher a révélé des associations statistiquement significatives entre les foyers de CPSC précédents et le foyer clinique ($P < 0,001$). Les auteurs ont décelé l'occlusion ou la sténose de l'artère coronaire qu'ils pensaient reliée à l'infarctus chez tous les patients, sous forme de lésion unique ou conjointement avec d'autres lésions de l'artère coronaire.

CONCLUSIONS : Les critères de CPSC proposés conviennent pour déceler les foyers d'IMI les plus fréquents. Il devient alors possible de distinguer un rétrécissement des artères coronaires reliées à l'infarctus, soit l'artère coronaire descendante antérieure ou postérieure.

ventriculography. Myocardial scintigraphy may show a perfusion defect, and coronary artery lesions (stenosis or occlusion) may be apparent on coronary arteriography, increasing the possibility of an old NQMI. However, these examinations cannot always prove the presence of remote NQMI.

Diagnosis of NQMI with body surface potential mapping

Previous body surface potential mapping (BSPM) publications have reported the possibility of diagnosing anterior and inferior NQMI, but

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Figure 1 Characteristic body surface isopotential maps of the first anterior minimum potential. The left side of each figure indicates anterior chest and the right side indicates posterior. **Top** Anteroseptal non-Q wave myocardial infarction (NQMI); **Middle** Inferoseptal NQMI; **Bottom** Average of the normal maps. The first anterior minimums seen in the pathological cases (first two rows) are similar in their timing (earlier than in the normal map) and in their values (less negative than the -0.22 mV differential diagnostic value). Before the criteria presented here, these patterns were collectively referred to as anteroseptal/inferior middle NQMI. By analyzing the potential map recorded 2 ms earlier than the first anterior minimum, the localization of the more accentuated negativity now discriminates the anteroseptal (upper negativity [arrow]) or inferoseptal (bottom negativity [arrow]) NQMI. In the normal averaged map, the first anterior minimum appears 24 ms after QRS onset and its value is more negative than -0.22 mV. The time after QRS onset and the values of maximum and minimum potentials are given and the diagnostic features are indicated. The interval between isopotential contour lines is 0.2 mV on all maps

the reported sensitivities were low (1-6). The authors of the present study (7) have described a BSPM method that resulted in 91% sensitivity and 88% specificity. However, even with this approach, ascertaining the exact location of the lesions was not always possible. In particular, infarcts affecting the anteroseptal or inferoseptal middle regions were regrouped as a single region (7). Separating these two regions is important because infarctions in these areas occur frequently and their blood supply is distinct.

The present study discriminates the anteroseptal and inferoseptal NQMI by BSPM and correlates BSPM localization with clinical localization based on noninvasive and invasive cardiac examinations.

PATIENTS AND METHODS

One hundred nineteen patients with a previous NQMI (36 to 76 years of age, average 61 years; 85 men) from Montreal ($n=46$) and Budapest, Hungary ($n=73$), were examined using noninvasive and invasive cardiac methods (repeated ECG, BSPM, chest x-ray, TTE and coronary angiography). Before BSPM, patients received only noninvasive treatment with medication. The proposed investigation was approved by our respective ethics committees.

The clinical localization of the infarction was determined if two of the following three tests were concordant: wall motion disturbances detected by echocardiography, coronary angiography recorded at the time of BSPM or well-localized repolarization changes on ECG recorded during the acute phase of the MI. If the tests were not concordant, the patient was classified as "not localizable". These indicated anterior NQMI in 51 cases: group A (36 to 72 years of age, average 59 years; 42 men) and inferior NQMI in 56 cases: group B (43 to 76 years of age, average 63 years; 34 men). In addition, in 12 cases, the NQMI could not be localized based on these criteria.

The control group consisted of 59 subjects (23 to 72 years of age, average 56 years; 29 men) who had a normal ECG, cardiac ultrasound examination and laboratory findings, and no cardiac complaints.

BSPM (Montreal system, 63 unipolar leads [8]) was recorded when patients were stable with no acute repolarization changes on ECG. BSPM traces were evaluated using a method of analysis previously described (7). To improve the localization of anteroseptal or inferior middle regions, the isopotential maps at 2 ms, 4 ms, 6 ms and 8 ms were studied before the first anterior minimum time point, which is seen 10 ms to 22 ms after QRS onset (its value is less negative than -0.22 mV on the anterior side of the chest).

The distinction of the clinical localization of NQMI and the coronary artery lesions was evaluated according to the proposed BSPM localization with Fischer's exact test.

RESULTS

Discrimination of anteroseptal and inferoseptal NQMI

Using the above-mentioned BSPM diagnostic signs, electrical potential loss in the anteroseptal and inferior mid-regions was detected in 70 of 119 NQMI cases (44 to 76 years of age, average 61 years; 53 men); electrical potential loss affected other regions in 40 of 119 cases.

After investigating isopotential maps at different times that preceded the appearance of the first anterior minimum potential value, the investigators found that characteristic isopotential maps discriminating anteroseptal or inferoseptal electrical potential loss occurred 2 ms before this time. Characteristic BSPM changes suggesting anteroseptal localization (32 of 70 NQMI cases and two of 59 healthy cases) included a narrower anterolateral positive area between the posterior and anterior negativity, and the total (anterior and posterior) negativity was more accentuated on the upper part (in contrast to the lower part) of the maps (Figure 1, top row, right diagram). The BSPM changes of the suspected inferoseptal electrical potential loss (38 of 70 NQMI cases and two of 59 healthy patients) included narrower anterolateral positivity, and the total negativity was more accentuated on the lower part (in contrast to the upper part) of the maps (Figure 1, middle row, right diagram).

Other anterior BSPM localizations of NQMI (mid-septal, anteroseptal apical, anterior paraseptal and anterosuperior middle) were diagnosed in 17 of 70 NQMI cases and in one of 59 healthy cases. Other inferoposterior BSPM localizations (posterolateral, inferior basal and inferior apical) were found in 23 of 70 NQMI cases and in five of 59 healthy cases.

Table 1 summarizes the BSPM localization of the cases, their distribution according to the clinical NQMI localization (anterior, inferior and clinically not localizable NQMIs), as well as healthy subjects. Sensitivity and specificity values of the BSPM localizations are given (the nonclinically localizable cases were considered to be false-positive; therefore, specificity may actually be better than is shown in the table). Concerning the distribution of the NQMI according to the clinical localization, Fisher's exact test showed significant distinction between any anterior and inferior BSPM localization, suggesting that there is an association between the BSPM and clinical localization of the NQMI.

Relationship between BSPM localization and coronary artery lesions
Coronary arteriography detected occlusions or narrowing in all NQMI patients. The lesion of the infarct-related coronary artery belonging to the supposed BSPM localization of the NQMI was detected in every

TABLE 1
Comparison of body surface potential mapping (BSPM) with clinical data

	BSPM localization			Clinical localization			Healthy, n
				Non-Q myocardial infarction, n			
	Number of patients	Sensitivity, %	Specificity, %	Anterior	Inferior	Not localizable	
Anteroseptal	34	93	90	28	3	1	2
Other anterior	18	88	95	15	2	0	1
Inferoseptal	40	81	84	3	30	5	2
Other inferior/posterolateral	28	67	78	3	14	6	5
Nonpathological changes	58	—	—	2	7	0	49

Number of cases: clinical localization of the non-Q wave myocardial infarction and healthy subjects according to BSPM localization. Clinical values of the BSPM localization are shown, and nonlocalizable cases were considered to be false-positive. Independence between clinical localizations was assessed by Fisher's exact test. $P < 0.001$ for anteroseptal/other anterior and inferoseptal/other inferior/posterolateral locations

case. Single-vessel disease was detected in 53% of anteroseptal cases, 41% of other anterior cases, 55% of inferoseptal cases and in 48% of other inferior NQMI cases, while in the remaining NQMI cases, the lesion of the infarct-related coronary artery coexisted with obstruction or narrowing of other coronary arteries.

With regard to the distribution of the coronary artery lesions according to the BSPM localization, Fisher's exact test showed a significant association between BSPM localizations and coronary artery lesions (Table 2).

DISCUSSION

Localization of previous NQMI (no significant Q waves) can be a difficult task. In our cohort, TTE, acute phase ECG and coronary angiography gave an approximate (anterior or inferior) localization in 90% of NQMI cases. Our refined BSPM method, described above, resulted in a more exact localization in 92% of NQMI patients.

The proposed method is suitable to discriminate between the most frequent NQMIs – anteroseptal and inferoseptal mid-region infarcts. The association between BSPM and clinical localization of NQMI, as well as the consistent presence of lesions in the infarct-related coronary artery, supports the notion that localization of NQMI using the proposed BSPM analysis is possible. The BSPM separation of anteroseptal and inferoseptal NQMI localizations provides clinically important information despite normal ECG patterns, because lesions of the left anterior descending or posterior descending coronary arteries can be detected.

Limitations

The projection of heart regions onto the body surface are variable among individual patients due to the rotation of the heart and differences in the size and shape of the chest. The healthy control group did not undergo coronary angiography. Also, this method cannot discriminate between necrosis and hibernating myocardium, which may have prognostic and therapeutic implications. There was no separate test group.

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TABLE 2
Body surface potential mapping (BSPM) and lesions determined by coronary angiography

	BSPM localization		
	Number of patients	Expected infarct-related coronary artery	Lesions by coronary angiography
Anteroseptal	32	LAD	LAD: 17 LAD + RC/CX: 15
Other anterior	17	LAD	LAD: 7 LAD + RC/CX: 10
Inferoseptal	38	RDP	PD (RC): 20, PD (CX): 1 PD (RC) + LAD/CX: 17
Other inferior/posterolateral	23	RCP/CX	PD (RC): 9, PD (CX): 2 PD (RC) + LAD/CX: 12
Not localizable	9		PD (RC): 2 PD (RC) + LAD/CX: 7

The expected infarct-related coronary artery and the coronary artery lesions determined by coronary angiography for BSPM localization of non-Q wave myocardial infarction. Fisher's exact test was used to assess the association between the coronary lesions and BSPM localization. $P < 0.001$ for anteroseptal/other anterior and inferoseptal/other inferior/posterolateral locations. CX Circumflex; LAD Left anterior descending; PD Posterior descending; RC Right coronary; RCP Right posterior coronary; RDP Right posterior descending

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