Nuclear Medicine Review 2008
Vol. 11, No. 2, pp. 59–66

ISSN 1506–9680

VIA MEDICA

Original

Effect of attenuation correction on normal ^{99m}Tc-MIBI myocardial perfusion scintigrams acquired with a hybrid SPECT/CT camera

Anna Płachcińska[1], Jakub Siennicki[1], Katarzyna Kovacevic-Kuśmierek[1], Małgorzata Bieńkiewicz[1], Jacek Kuśmierek[2]

[1]Department of Quality Control and Radiological Protection, Medical University, Łódź, Poland
[2]Department of Nuclear Medicine, Medical University, Łódź, Poland

[Received 25 I 2009; Accepted 28 I 2009]

Abstract

The aim of this study was to evaluate the effect of the CT-derived attenuation correction on ^{99m}Tc-MIBI normal myocardial perfusion scintigrams. Rest perfusion scintigrams of patients in whom coronary artery disease was suspected, without a history or any signs in ECG of a myocardial infarction, were analysed. Patients were included in the material if their rest perfusion scintigrams were normal. This criterion was fulfilled by 61 patients (29 men and 32 women) aged between 40 and 74 (mean value 57) years, with body mass between 50 and 120 (mean value 70) kg. Tomographic reconstruction of a radionuclide study was performed with an iterative OSEM method (10 subsets, 2 iterations) sequentially without and with attenuation and scatter corrections on a dedicated Xeleris workstation, applying an ACQC tool to enable manual realignment of SPECT and CT images. SPECT studies were evaluated visually and semiquantitatively. Visual analysis of tomograms was performed with the aim of finding sites of significantly lower counts in comparison with the maximal level (in the lateral wall). Semiquantitative analysis was based on counts in 20 segments of a polar map. Attenuation correction caused a complete (in 32 of 40 — 80% of patients) or partial (in 8 of 40 — 20% of patients) filling out of all areas of lower counts in the inferior wall. However, although in the anterior wall attenuation correction caused a complete (in 11 of 35 — 31% of cases) or partial (10 of 35 — 29% of cases) filling of areas of lower counts, in 14 cases (40%) those areas remained unchanged or increased, and in 8 cases (13% of all patients) new areas of decreased counts appeared. The same was true for the apical region, in which areas of decreased counts were detected in 14 of 61 (23%) cases without attenuation correction, but after application of the correction number of apical defects, this figure grew to 22 (36%) patients. Altogether, attenuation correction reduced the total number of lower count areas from 104 to 66. Semi-quantitative analysis revealed that attenuation correction reduced nonuniformity in counts in the whole myocardium — the mean difference between segment with maximum counts and values in all segments was reduced from 17.5 ± ± 12% to 11.0 ± 10.3% ($p < 0.0001$) in male patients, and in female patients, from 11.5 ± 9% to 10.5 ± 8.6%, thus equalling non-uniformities in myocardial scintigrams of both sexes. Misalignment of CT and SPECT studies was observed in 17 (28%) patients but only in 2 (3% of all patients) patients did CT realignment evidently change the attenuation corrected scintigrams.

Although attenuation correction can cause artefacts, its use is justified by the reduction of the total number of areas of lower counts and the improvement of uniformity of images of normally perfused myocardium.

Key words: attenuation correction, perfusion study, CT misalignment

Nuclear Med Rev 2008; 11, 2: 59–66

Correspondence to: Anna Płachcińska
Department of Quality Control and Radiological Protection,
Central Teaching Hospital
ul. Czechoslowacka 8/10, 92–216 Łódź, Poland
email: anna@csk.umed.lodz.pl

Introduction

The absorption of gamma rays by a patient's body significantly affects scintigraphic images. This phenomenon is particularly important in the case of myocardial perfusion images. In such studies, a smaller fraction of radiation emitted from parts of the myocardium located deeper in the body (*e.g.* the inferior wall) reaches the gamma camera detectors than the fraction of quanta emitted from parts of the myocardium located at a lesser depth, such as an apex. In addition, it is commonly assumed that the frequently observed regions of lower activity in the anteroseptal wall in females are cause by radiation absorption in the breasts. The abovementioned situations, occurring as spurious, less intensive accumulation of a radiopharmaceutical in the inferior wall in males, in whom the effect is more pronounced due to a thicker diaphragmatic muscle, as well as in the antero-septal wall in females, frequently result in diagnostic difficulties.

Due to these circumstances, the introduction of correction of gamma ray attenuation with an exterior source of radiation led to the desire to assess the effectiveness of respective procedures while studying myocardial perfusion. Initially a radioactive source (*e.g.* Gadolinium-153) and later X-rays (in hybrid SPECT/CT cameras) were used for this purpose. Communications related to this issue indicate both the diagnostic benefits and additional artefacts resulting from such corrections [1–4]. In addition, among the drawbacks of a CT-derived correction, a relatively long time interval between acquisitions of SPECT and CT studies is mentioned, giving the opportunity for patient movement among these studies.

The aim of this study was to evaluate the effect of CT-derived attenuation correction on ^{99m}Tc-MIBI normal myocardial perfusion scintigrams.

Material and methods

The rest perfusion scintigrams of patients in whom coronary artery disease was suspected, without a history or any signs in ECG of a myocardial infarction, were analysed. Patients were included in the material if their rest perfusion scintigrams, assessed visually by an experienced nuclear medicine specialist, were normal. This criterion was fulfilled by 61 patients (29 men and 32 women) aged between 40 and 74 (mean value 57) years, with body mass between 50 and 120 (mean value 70) kg.

^{99m}Tc-MIBI was used as a radiopharmaceutical, administered in activities depending on the patient's body mass — 11 MBq per kilogram. Acquisition of rest perfusion study was started after 1-hour post administration of the radiopharmaceutical. Patients were placed on a bed in a supine position, with the left arm held above the head. SPECT studies were acquired on a dual-head Hawkeye gamma camera (GE) with perpendicular detectors (in L-mode) fitted with low energy high-resolution collimators (energy windows — 140 ± 10% and 120 ± 5%), rotating between RPO 45° (right posterior oblique) and LAO 45° (left anterior oblique) positions in a step-and-shoot mode along a circular orbit. Each projection lasted 25 seconds. Studies were acquired with a zoom factor of 1.28 and stored in a 64 × 64 matrix. After completion of a radionuclide study, acquisition of a low-dose CT study (140 kV, 2.5 mA, axial resolution — 5 mm) of part of the patient's body encompassing the heart was started.

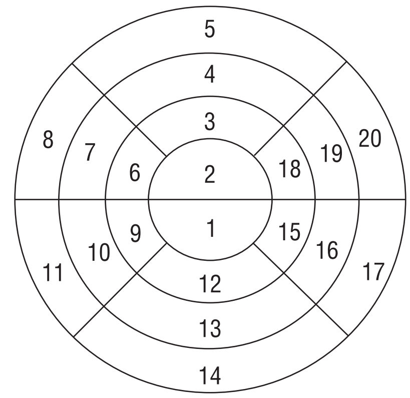


Figure 1. Scheme of division of a left ventricular myocardium (polar map) into 20 segments. 1 — apex inferior; 2 — apex superior; 3 — apical anterior; 4 — mid-anterior; 5 — basal anterior; 6 — apical anteroseptal; 7 — mid-anteroseptal; 8 — basal anteroseptal; 9 — apical inferoseptal; 10 — mid-inferoseptal; 11 — basal inferoseptal; 12 — apical inferior; 13 — mid-inferior; 14 — basal inferior; 15 — apical inferolateral; 16 — mid-inferolateral; 17 — basal inferolateral; 18 — apical anterolateral; 19 — mid-anterolateral; 20 — basal anterolateral.

Tomographic reconstruction of the radionuclide study was performed with an iterative OSEM method (10 subsets, 2 iterations, Butterworth filter of power 5, cutoff frequency 0.52) sequentially without and with attenuation and scatter correction on a dedicated Xeleris workstation, with the application of an ACQC tool enabling manual realignment of SPECT and CT studies (in case the latter study was shifted) along 3 axes (x — lateral, y — ventrodorsal, and z — craniocaudal shifts).

SPECT studies were evaluated visually and semiquantitatively. Visual analysis of transversal, coronal, and sagittal tomograms were performed with the aim of finding sites of significantly lower counts in comparison with the maximal level (in the lateral wall). Semiquantitative analysis was based on counts in 20 segments of a polar map, as presented in Figure 1.

Statistical significance of differences between mean values in segments before and after attenuation correction was tested with Wilcoxon test for paired values.

Results

Visual analysis

Evaluation of scintigrams was carried out in groups of men and women separately. Results of the visual analyses are presented in Tables 1 and 2. In the group of men, the sites of lower counts were located predominantly in the inferior wall, whereas in the group of women they were located mainly in the anterior wall. In 23 of 29 (79%) male patients, attenuation correction caused a complete, and in 6 (21%) a partial, filling of lower count areas in the inferior wall. In the group of female patients, all the sites of lower counts in the inferior wall were filled completely (in 9 of 11 patients — 82% of

Table 1. Numbers of areas with reduced counts localized in respective myocardium walls, before and after attenuation correction, in groups of male and female patients — men

Location	Before attenuation correction	After attenuation correction				
	Lower count areas	Lower count areas				
		Resolved	Reduced	Unchanged	Enlarged	New
Apex	7	–	–	7	–	2
Anterior wall	9	2	2	4	1	6
Septum	5	5	–	–	–	–
Inferior wall	29	23	6	–	–	–
Lateral wall	3	3	–	–	–	–

Table 2. Numbers of areas with reduced counts localized in respective myocardium walls, before and after attenuation correction, in groups of male and female patients — women

Location	Before attenuation correction	After attenuation correction				
	Lower count areas	Lower count areas				
		Resolved	Reduced	Unchanged	Enlarged	New
Apex	7	–	–	5	2	6
Anterior wall	26	9	8	9	–	2
Septum	7	5	1	1	–	2
Inferior wall	11	9	2	–	–	–
Lateral wall	–	–	–	–	–	–

cases) or partially (in 2 of 11 — 18% of cases) after attenuation correction. Altogether, attenuation correction caused a complete (in 32 of 40 — 80% of cases) or partial (in 8 of 40 — 20% of patients) filling of areas of lower counts in the inferior wall of all patients.

However, in the anterior wall, attenuation correction was not so effective. In the group of female patients it caused a complete filling (in 9 of 26 — 35% of cases) or reduction (in 8 — 31% of cases) of areas of lower counts only in some cases. In the remaining 9 cases (35%) those areas remained unchanged, and new cases could be observed in 2 patients (7% of all female patients). In the group of male patients, out of 9 (31% of men) areas of reduced counts in the anterior wall, 2 (22%) disappeared, the next 2 (22%) were reduced, the next 4 (44%) remained unchanged, 1 (11%) was enlarged, and 6 new cases (in 21% of all male patients) could be observed. In all patients taken together, in the anterior wall attenuation correction caused a complete (in 11 of 35 — 31% of cases) or partial (10 of 35 — 29% of cases) filling of areas of lower counts, in 14 cases (40%) those areas remained unchanged or increased, and in 8 cases (13% of all patients) new areas of decreased counts appeared.

In the apex in groups of male as well as female patients 7 (together 14) areas of reduced counts were observed before application of attenuation correction. In male patients all those areas remained unchanged and 2 additional sites appeared after attenuation correction, and in female patients 5 apical areas of reduced counts remained unchanged, 2 were enlarged and 6 new sites could be observed as a result of attenuation correction. Altogether, areas of decreased counts were detected in 14 of all 61 (23%) cases without attenuation correction, but after application of the correction, the number of apical defects grew to 22 (in 36% of patients).

In the septal and lateral walls, almost all (except 1) areas of reduced counts were filled out by attenuation correction. An example of a case of attenuation correction induced area of reduced counts in the anterior wall is presented in Figure 2.

The net effect of attenuation correction proved positive because it reduced the total number of lower count areas (Tables 1 and 2, male and female patients taken together) from 104 (before correction) to 66 (after correction).

Semiquantitative analysis

Mean values of counts in respective segments of left ventricular myocardium, together with standard deviations, before and after attenuation correction for both sexes are presented in Table 3.

In the group of male patients attenuation correction reduced mean counts in the apex superior and apical anterior segments, whereas in all the remaining segments except the apex inferior, apical anterolateral, and basal anteroseptal, mean counts were statistically significantly increased (Figure 3A). This change of counts in the majority of segments caused a substantial reduction of nonuniformity in counts in the whole left ventricular myocardium — the mean difference between maximum counts (in apical anterolateral segment) and values in all segments was reduced from $17.5 \pm 12\%$ to $11.0 \pm 10.3\%$ ($p < 0.0001$).

In the group of female patients, attenuation correction reduced counts in the apex inferior and anterior, whereas in all the remaining segments except the apical anterior, anterolateral, inferolateral, and mid anterolateral, mean counts were statistically significantly increased (Figure 3B). In female patients, the reduction of nonuniformity in counts in the whole left ventricular myocardium was only minor (from $11.5 \pm 9\%$ to $10.5 \pm 8.6\%$), but in effect, the attenuation correction practically equalled the nonuniformities in both sexes (11.0% in males *versus* 10.5 % in females).

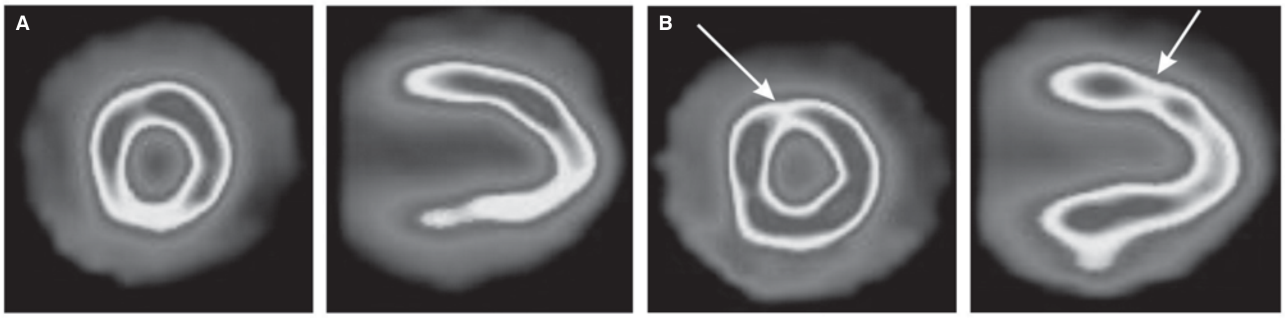


Figure 2. Example of an artifact (arrows) in anterior wall on transversal and sagittal SPECT tomograms after attenuation correction. **A.** Before attenuation correction; **B.** After attenuation correction.

Table 3. Mean counts in 20 segments of left ventricular myocardium, before and after attenuation correction (AC), in groups of men and women; p-levels of significance. Meaning of segment numbers — see Figure 1

No. of	Men (n = 29)			Women (n = 32)		
segment	Before AC	After AC	p	Before AC	After AC	p
1	76.5 ± 5.8	75.8 ± 4.5	0.33	79.3 ± 6.0	74.8 ± 6.1	0.00002
2	80.2 ± 5.1	76.0 ± 4.3	0.00006	75.8 ±.6.5	73.2 ± 5.7	0.004
3	81.8 ± 4.1	79.2 ± 3.8	0.0052	76.5 ± 6.5	77.3 ± 5.2	0.46
4	77.7 ± 5.0	80.3 ± 4.7	0.0008	77.2 ± 6.2	80.7 ± 4.4	0.0013
5	66.8 ± 6.8	69.3 ± 8.1	0.012	67.9 ± 6.7	70.8 ± 6.2	0.0024
6	82.8 ± 4.0	85.1 ± 3.2	0.002	80.2 ± 4.6	82.4 ± 4.6	0.0032
7	75.8 ± 5.4	80.8 ± 5.1	0.00004	77.4 ± 6.0	82.6 ± 6.2	0.00001
8	50.1 ± 8.4	51.4 ±10.7	0.199	57.8 ± 9.4	59.4 ± 8.5	0.026
9	80.0 ± 5.8	88.2 ± 3.3	0.000003	83.7 ± 4.5	85.3 ± 4.9	0.006
10	67.3 ± 5.8	80.7 ± 5.2	0.000003	75.1 ± 5.9	80.9 ± 7.2	0.00004
11	44.8 ± 6.4	53.5 ± 8.3	0.000004	54.4 ± 7.3	58.7 ± 7.6	0.00002
12	70.3 ± 5.5	81.8 ± 3.9	0.000003	80.7 ± 6.6	83.9 ± 4.7	0.004
13	63.7 ± 4.6	81.4 ± 4.2	0.000003	77.8 ± 5.5	85.7 ± 4.1	0.000001
14	52.4 ± 5.5	69.3 ± 6.6	0.000003	66.0 ± 6.9	73.6 ± 6.1	0.000002
15	81.1 ± 5.9	87.2 ± 4.3	0.000012	87.2 ± 4.1	86.7 ± 5.8	0.97
16	73.6 ± 5.6	85.1 ± 4.7	0.000003	84.8 ± 5.9	88.4 ± 4.4	0.0005
17	64.0 ± 6.3	75.0 ± 6.6	0.000003	75.7 ± 8.0	79.8 ± 6.5	0.00004
18	89.4 ± 3.0	88.6 ± 3.1	0.30	86.5 ± 5.4	86.5 ± 4.2	0.88
19	85.1 ± 5.0	87.9 ± 4.0	0.007	87.9 ± 5.2	89.4 ± 3.1	0.14
20	72.6 ± 7.0	75.9 ± 6.2	0.004	76.5 ± 6.2	78.5 ± 5.6	0.057

Artefacts caused by attenuation correction

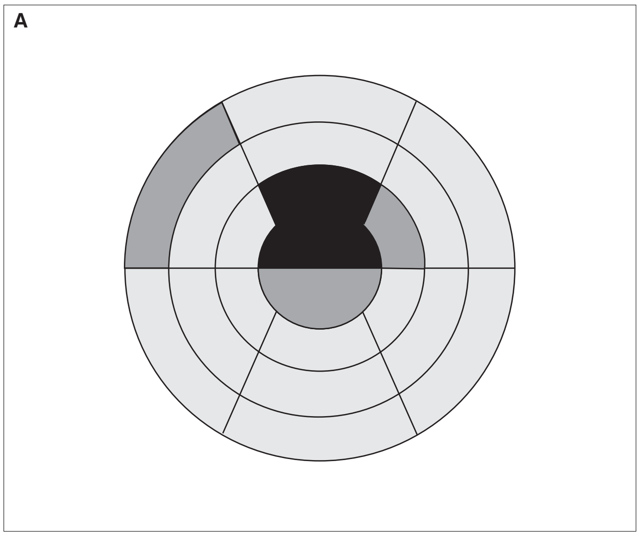
Misalignment of CT and SPECT studies

Such a misalignment was observed in 17 (28%) of the patients studied; in the majority of cases this resulted from a shift of the CT study along the X- or Z-axis (isolated shift along the X-axis — 8 cases, along both the X- and Z-axes — 5 cases; the remaining 2 — along the Z-axis and only 1 case along 3 axes) — Table 4. Studies were realigned using a fusion/registration software tool provided by the manufacturer (ACQC tool — GE) and reconstructed again, applying attenuation correction.

In 11 cases those realignments (along the X-axis from 4.4 mm to 15.6 mm, along the Z-axis from 2 to 6.8 mm) did not result in visually perceptible differences in attenuation corrected scintigrams, although in several cases the misalignments substantially exceeded the pixel size (6.9 mm). In the remaining 4 of 6 cases scintigrams were changed only slightly. Only in 2 cases did the CT realignment change the myocardial scintigrams evidently — their anterior and lateral and only the anterior wall. In both cases the misalignment of CT was substantial (along the X-axis 11.2 mm, along the Z-axis — 10mm, and isolated along the Z-axis — 9 mm) and caused a partial overlapping of the myocardium (its anterior and lateral wall in one case and only the lateral wall in the second case) on a lung area in CT. This probably resulted in miscorrection of SPECT images. An example of the effect of a misaligned and realigned CT study on attenuation corrected myocardial perfusion scintigrams is presented in Figures 4 and 5.

Truncation of breasts

Reconstructed CT transversal slices were incomplete in several cases — parts of thorax images were truncated. This happened most often in females and affected the right breast, which in sever-



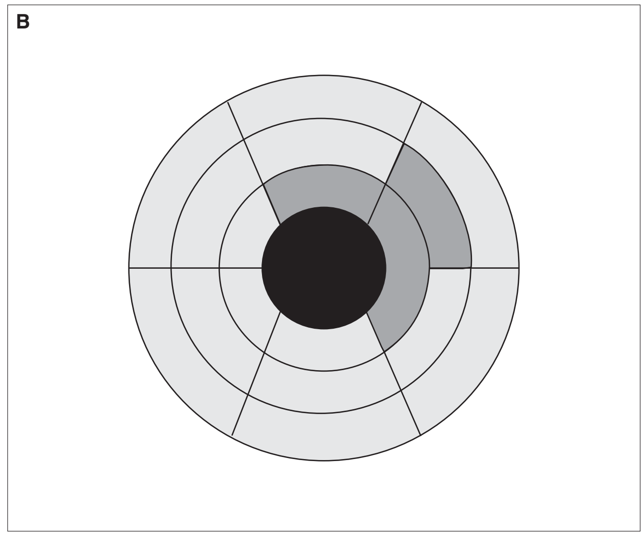


Figure 3. Changes of mean counts in segments of left ventricular myocardium after attenuation correction in groups of men (**A**) and women (**B**). Segments with statistically significantly decreased counts are presented in black, increased — in light grey, lack of statistical significance — in dark grey.

Table 4. Realignments of CT with respect to SPECT study along 3 axes

Patient No.	Realignment along axis			Cause of realignment	Effect of realignment on AC scintigrams (visually)
	X	Y	Z		
1	15.6	–	–	Anterior and lateral walls overlap on lung area	NC
2*	11.2	–	10	Anterior and lateral walls overlap on lung area	Evidently higher counts in anterior and lateral walls
3	–	–	6.4	Anterior wall overlaps on lung area	NC
4	4.4	–	–	Apex and lateral wall overlap on lung area	NC
5	17.8	–	–	Anterior and lateral walls overlap on lung area	Slightly higher counts in anterior wall
6*	–	–	9.0	Anterior wall overlaps on lung area	Evidently higher counts in anterior wall
7	4.8	–	–	Apex and lateral wall overlap on lung area	NC
8	5.2	–	7,8	Anterior wall overlaps on lung area	Slightly higher counts in anterior wall
9	5.4	–	–	Anterior wall overlaps on lung area	NC
10	–	–	6.8	Inferior wall overlaps on stomach	Slightly higher counts in apex
11	7.6	–	–	Apex and lateral wall overlap on lung area	NC
12	4.8	–	9.6	Anterior and lateral walls overlap on lung area	Slightly lower counts n apex
13	5.0	–	–	Anterior and lateral walls overlap on lung area	NC
14	6.6	–	–	Anterior wall and apex overlap lung area	NC
15	6.2	–	4.6	Anterior and lateral walls overlap on lung area	NC
16	6.2	8.6	7.8	Anterior and lateral walls overlap on lung area	Slightly higher counts in apex, slightly lower counts in inferior wall
17	5.2	–	2.0	Anterior wall overlaps lung area	NC

X — latteral; Y — ventrodorsal; Z — craniocaudal; NC — no change; AC — attenuation correction; *Patients in whose attenuation corrected scintigrams CT realignment caused evident changes (No. 2 and 6)

al cases was truncated in a substantial part (Figure 6). In a few cases a similar result was also seen in males in whom a part of the thorax soft tissues were also truncated. This result affected the correction map and probably the effectiveness of attenuation correction. A substantial effect of this kind was observed in 5 women, mostly those with large breasts.

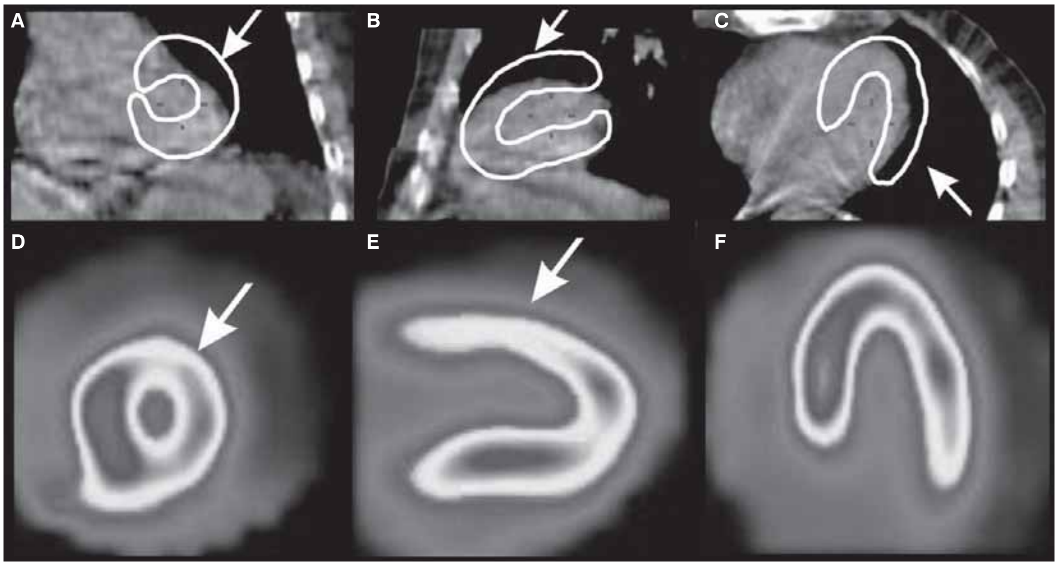


Figure 4. Example of an artifact caused by misalignment between SPECT and CT studies. CT tomograms in three planes with contours of left ventricular myocardium and attenuation corrected scintigrams. Arrows show overlapping of anterior and lateral walls on the lung area and artifacts on scintigrams caused by erroneous attenuation correction. **A.** Fused coronals; **B.** Fused sagittals; **C.** Fused transaxials; **D.** Attenuation corrected (AC) SPECT — short axis; **E.** AC SPECT — vertical axis; **F.** AC SPECT — horizontal axis.

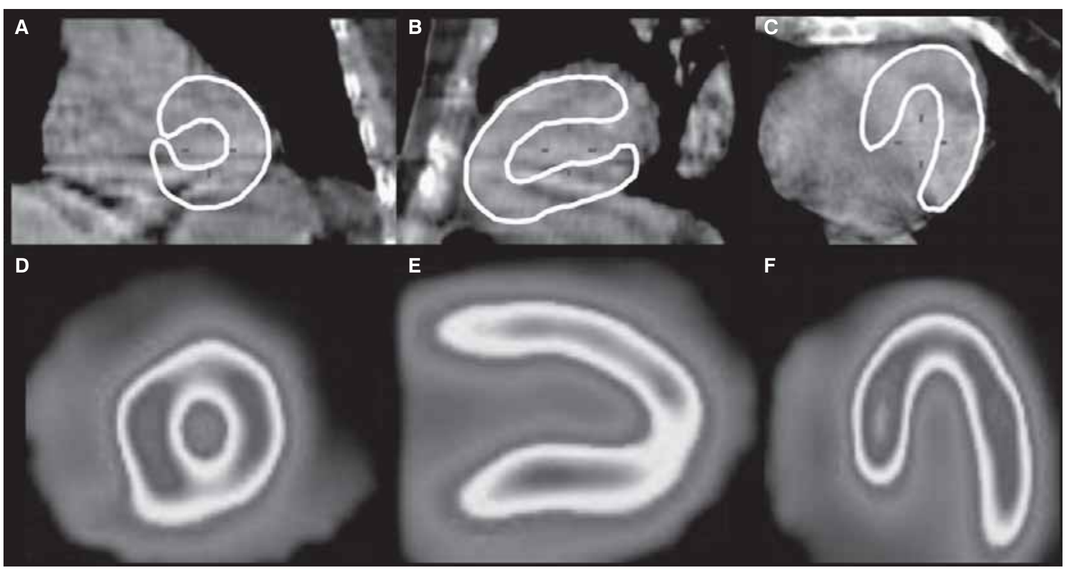


Figure 5. The same scintigrams as in Fig.4 after realignment of CT. **A.** Fused coronals; **B.** Fused sagittals; **C.** Fused transaxials; **D.** Attenuation corrected (AC) SPECT — short axis; **E.** AC SPECT — vertical axis; **F.** AC SPECT — horizontal axis.

Discussion

Attenuation correction applied in myocardial perfusion studies acts in two opposite directions: on one hand, due to reduction of artefacts observed in the inferior wall, it facilitates the assessment of perfusion of this wall. On the other hand, the correction introduces some new artefacts localised in the anterior wall and apex. Due to this observation, there are diverging opinions as to the appropriateness of applying this correction, some of them negative [5]. In recent years, positive opinions on applying the attenuation correction have seemed to prevail, particularly due to results of a multicentre study on the diagnostic efficacy of attenuation corrected SPECT myocardial perfusion [4]. The authors of this work demonstrated that attenuation correction improved the diagnostic efficacy of the procedure, mostly by reduction of the number of false positive results. On the other hand, in 2008 a report appeared claiming that in women attenuation correction does not improve the diagnostic efficacy of myocardial perfusion studies [6]. In a joint statement, the American Society of Nuclear Cardiology and the Society of Nuclear Medicine have recommended that both non-corrected and corrected image sets be reviewed and integrated into the final report [7], as an experienced nuclear medicine specialist will be able to identify artefacts in the anterior wall and apex that are present only in the attenuation

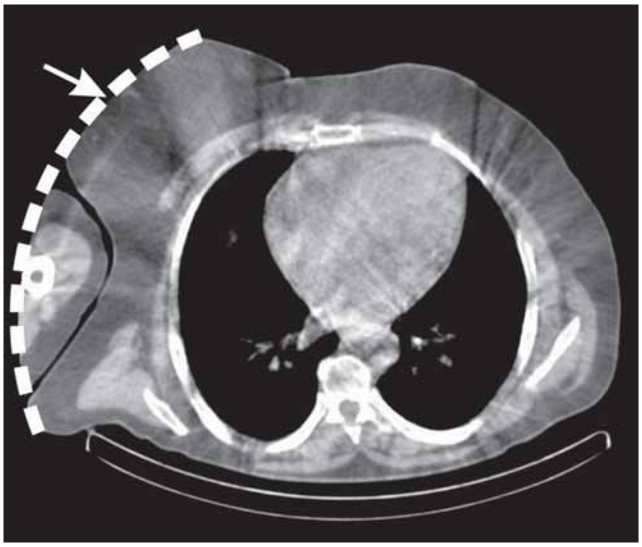


Figure 6. Example of transversal CT tomograms used for the purose of creation of attenuation correction map. Thick white dotted line shows a line of image truncation (limit of a field of reconstruction). A part of patient's right breast is outside of image recontruction field.

corrected images. This position adequately reflects the limitations of the methods used at present for attenuation correction. It appears that if attenuation correction is to be applied routinely, corrected as well as uncorrected images should be assessed. In our material the increased incidence of perfusion defects in the anterior wall after attenuation correction was seen mostly in males in whom the number of areas of lower counts increased noticeably after attenuation correction. In females, a similar effect was observed mostly in the apex. However, the net effect of attenuation correction was positive because it reduced the total number of areas of lower counts in images of normal myocardium (in male and female patients).

The next source of uncertainty in interpretation of CT attenuation corrected perfusion scintigrams results from patient movement during or between SPECT and CT studies. There are several publications devoted to this problem [8–10]. Some authors conclude that study misalignment resulting from patient movement occurs in the majority of studies [9] and that even a misalignment smaller than one pixel may have a significant effect on corrected SPECT images [8]. Our study does not confirm such frequent movements of patients, nor does it confirm any remarkable negative impact on attenuation corrected images. In numerous cases, it was difficult to say if the patient really moved. This was due to the suboptimal quality of low-dose CT images, substantial difference between resolutions of SPECT and CT studies, and the lack of internal landmarks easily discernible in both SPECT and CT. For these reasons, one should not be surprised by the conflicting opinions of various authors on the subject. In our material the easiest observation was the lateral shift of a patient (along the X-axis), resulting in overlapping of the scintigram on a fused image on the lung area on CT. However, our study did not confirm any highly significant effect of small patient shifts on attenuation corrected scintigrams. Among the 17 patients in whom we observed CT misalignment, there was a clear influence of erroneous attenuation correction on scintigrams only in 2 cases (12%). In the remaining cases, in spite of the fact that in some of them the shift exceeded the pixel size, the errors of correction were unobservable. To summarize, in the opinion of the authors of this study, misalignment of CT and SPECT studies is not such a common source of erroneous image correction as one would think from inspection of the literature. The situation could possibly be worse in the case of heavy patients, where, according to Fricke et al [8], a bed deflection becomes essential, leading to misalignment of CT along the Y-axis (ventrodorsal shift).

The runcation of female patients' right breasts, observed in our study, can cause artefacts in attenuation correction. Therefore, it should be recommended that female patients hold both arms above their head. However, this effect, i.e. a limited area of transversal tomogram reconstruction, may also lead to the truncation of some exterior parts of soft tissues of the thorax in heavy patients (also males), and therefore produce artefacts in attenuation correction.

Summarizing, it appears that attenuation correction of myocardial perfusion scintigrams, although reducing artefacts in the inferior wall of left ventricular myocardium, introduces new artefacts in the anterior wall and apex. These effects are not the result of CT and SPECT misalignment. However, the net effect of attenuation correction is positive because it reduces the total number of areas of lower counts in the myocardium. Finally, attenuation correction in patients with high body mass and/or large thorax dimensions may be subject to errors resulting from a limited field of reconstruction of transversal CT tomograms, which may lead to erroneous correction due to truncation of the outer parts of thorax soft tissues.

Work financed by the Medical University in Łódź, Poland, fund No 502-18-671

References

1. Corbett JR, Ficaro EP. Clinical review of attenuation-corrected cardiac SPECT. J Nucl Cardiol 1999; 6: 54–68.
2. Utsunomiya D, Tomiguchi S, Shiraishi S et al. Initial experience with X-ray CT based attenuation correction In myocardial perfusion SPECT imaging using a combined SPECT/CT system. Annals of Nuclear Medicine 2005: 19: 485–489.
3. Kjaer A, Cortsen A, Rahbek B et al. Attenuation and scatter correction in myocardial SPET: improved diagnostic accuracy in patients with suspected coronary artery disease. Eur J Nucl Med Mol Imaging 2002; 29: 1438–1442.
4. Masood Y, Liu YH, Depuey G et al. Clinical validation of SPECT attenuation correction using X-ray tomography-derived attenuation maps: multicenter clinical trial with angiographic correlation. Journal of Nuclear Cardiology; 2005; 12: 676–686.
5. Wackers FJ. Should SPET attenuation correction be more widely employed in routine clinical practise? Against. Eur J Nucl Med Mol Imaging 2002; 29: 412–415.
6. Wolak A, Slomka PJ, Fish MB et al. Quantitative diagnostic performance of myocardial perfusion SPECT with attenuation correction in women. J Nucl Med 2008; 49: 915–922.
7. Hendel RC, Corbett JR, Cullom SJ et al. The value and practice of attenuation correction for myocardial perfusion SPECT imaging: a joint

position statement from the American Society of Nuclear Cardiology and the Society of Nuclear Medicine. J Nucl Cardiol 2002; 9: 135–143.
8. Fricke H, Fricke E, Weise R. A method to remove artifacts in attenuation-corrected myocardial perfusion SPECT introduced by misalignment between emission scan and CT-derived attenuation maps. J Nucl Med 2004; 45: 1619–1625.
9. Goetze S, Brown T, Lavely W et al. Attenuation correction in myocardial perfusion SPECT/CT: effects of misregistration and value of reregistration. J Nucl Med 2007: 48: 1090–1095.
10. Takahashi Y, Murase K, Higashino H et al. Attenuation correction of myocardial SPECT images with X-ray CT: effects of registration errors between X-ray CT and SPECT. Ann Nucl Med 2002: 16: 431–435.