INVITED REVIEW ARTICLE

Normal values for nuclear cardiology: Japanese databases for myocardial perfusion, fatty acid and sympathetic imaging and left ventricular function

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Abstract Myocardial normal databases for stress myocardial perfusion study have been created by the Japanese Society of Nuclear Medicine Working Group. The databases comprised gender-, camera rotation range- and radiopharmaceutical-specific data-sets from multiple institutions, and normal database files were created for installation in common nuclear cardiology software. Based on the electrocardiography-gated single-photon emission computed tomography (SPECT), left ventricular function, including ventricular volumes, systolic and diastolic functions and systolic wall thickening were also analyzed. Normal databases for fatty acid imaging using ^{123}I-beta-methyl-iodophenyl-pentadecanoic acid and sympathetic imaging using ^{123}I-meta-iodobenzylguanidine were also examined. This review provides lists and overviews of normal values for myocardial SPECT and ventricular function in a Japanese population. The population-specific approach is a key factor for proper diagnostic and prognostic evaluation.

Keywords Normal database · Myocardial perfusion imaging · Systolic and diastolic function · ^{123}I-BMIPP database · ^{123}I-MIBG database

In nuclear cardiology, myocardial perfusion single-photon emission computed tomography (SPECT) plays important roles for diagnosis, guiding therapeutic strategies, evaluation of therapeutic effects and in predicting future cardiac events. Although recent technological advances in cardiac imaging modalities are remarkable, nuclear cardiology guidelines have been made in the United States and Japan, and a large amount of evidence has supported the use of radionuclide imaging in patients with acute syndromes, chronic syndromes and heart failure [1, 2]. Practical approaches for specific populations have also been recommended in nuclear cardiology guidelines.

The first step of image-based diagnosis is careful visual interpretation of myocardial images. Quantitative evaluation using myocardial perfusion imaging, however, aids diagnostic accuracy and enhances diagnostic certainty by reducing borderline interpretations. Various software programs have been developed, and more sophisticated and user-friendly approaches have been under development [3–5]. Common quantitative features of these software programs included calculating myocardial count on SPECT slices using appropriate segmentations and displaying the quantitative values on polar maps or three-dimensional surface maps. In the processing algorithm, individual patient data were compared with control databases from low likelihood of heart diseases. Therefore, characteristics of the standard database might have influenced the final diagnostic accuracy. The Japanese Society of Nuclear Medicine (JSNM) database was created as a working group activity from these background studies [6].

To diagnose Japanese patients, it is necessary to use a normal Japanese database—this is a simple assumption. However, is it actually critical for the diagnosis? In this review, we deal with this question and summarize the characteristics of the Japanese databases for myocardial perfusion, fatty acid imaging and sympathetic imaging. In addition, characteristics of left ventricular function based

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on a gated SPECT study are reviewed in a Japanese population.

Myocardial perfusion database

Myocardial perfusion imaging with either exercise or pharmacological stress provides fundamental information for diagnosis of ischemic heart diseases, and its clinical utility has been established based on nearly three decades of experience. Although an individual institution-specific normal database may best fit the acquisition method and study population, accumulating and validating normal databases usually require cumbersome steps. The major merit of the authorized common databases, if they are available, is that they can be safely used in most of the institutions where standard acquisition and stress protocols are used. In the working group activity involving multiple nuclear medicine centers; however, we could not add all our raw data into one common database. Considering the factors that influenced regional myocardial distribution, we separated databases by genders, 360° and 180° rotation acquisitions, and ^{201}Tl and ^{99m}Tc pharmaceuticals. Because ^{99m}Tc-tetrofosmin and ^{99m}Tc-methoxy-isobutyl isonitrile (MIBI) showed no statistical differences in tracer distribution by preliminary investigation, both ^{99m}Tc data types were added.

Nine hospitals collaborated on the normal database accumulation, and a total of 326 sets of exercise–rest myocardial perfusion images were accumulated from subjects with a low likelihood of cardiac diseases [6]. Using a DICOM (digital imaging and communications in medicine) format, projection images with gated and non-gated studies were anonymously transferred to the core laboratory of Kanazawa University. The reconstruction parameters for SPECT images were standardized and processed using the same computer (GE Yokogawa Medical Systems, Co, Ltd, Tokyo, Japan). The following software was available: QGS-QPS (Cedars-Sinai Medical Center, Los Angeles, CA, USA), Emory's Cardiac Toolbox (Emory University, Atlanta, GA, USA) and 4D-MSPECT (University of Michigan Medical Center, Ann Arbor, MI, USA). Although we have created standard database files for each software program, all the quantitative analyses written in this article are based on the QPS-QGS algorithm of quantification.

Figure 1 shows polar maps created by a normal Japanese population. When the 360° and 180° rotation methods were compared, septal segments showed higher values in the 180° rotation for both ^{99m}Tc and ^{201}Tl. Differences in genders were significant in the mid- and apical inferior segments showing lower values in men due to diaphragmatic attenuation. In females, apical anterior segments showed lower values due to breast attenuation. Differences between ^{201}Tl and ^{99m}Tc tracers were not negligible [6].

When the normal databases from the United States (Cedars-Sinai Medical Center database pre-installed in the standard QPS) and Japan were compared, attenuation in the anterior wall was greater in the American female population than in the Japanese population. Inferior diaphragmatic attenuation was greater in the American population in males. Does the small difference between nations actually influence the diagnostic accuracy? The diagnostic performance was evaluated by receiver-operating characteristic analysis among Japanese 360° and 180° acquisition databases (Jp360 and Jp180) and an American database with a 180° acquisition database (US180), when Japanese patients with a 360° acquisition method were analyzed [7]. Areas under the curve were the highest for Jp360 (0.842), followed by Jp180 (0.758) and US180 (0.728) databases ($P = 0.019$, Jp360 vs. US180; $P = 0.035$, Jp360 vs. Jp180). Because of the database difference in the inferior wall of male patients, diagnostic improvement was demonstrated in the right coronary artery territory (Fig. 2). Similarly, differences in the anterior wall in female patients resulted in improved accuracy in left anterior descending coronary territory. Thus, it was essential to use population- and acquisition-specific databases when using quantitative perfusion SPECT software. Clinical validation was subsequently performed when the same database could be used in various types of software and versions [8]. Five institutions participated in the study, and each used different acquisition settings that included 360° and 180° rotation ranges, camera configurations and camera orbits. The core laboratory created normal database files from the original JSNM short-axis image sets, which were fitted for each software version. Overall sensitivity, specificity and accuracy of patient-based analysis were 77, 72 and 75%, respectively, based on the quantitative analysis using the common database, whereas those by institutional visual expert reading were 72, 79 and 75%, respectively. Although the diagnostic accuracy was moderately good, the study indicated that the common database could be applicable to different institutions when such a database was appropriately created according to the software-specific database generator.

Left ventricular function in a Japanese population

A number of studies have demonstrated that gated SPECT evaluation of ejection fraction (EF), regional wall motion and wall thickening was accurate, and gated SPECT could be considered as an effective substitute modality of radionuclide ventriculography for the assessment of left ventricular function [9–12]. Although the reproducibility of
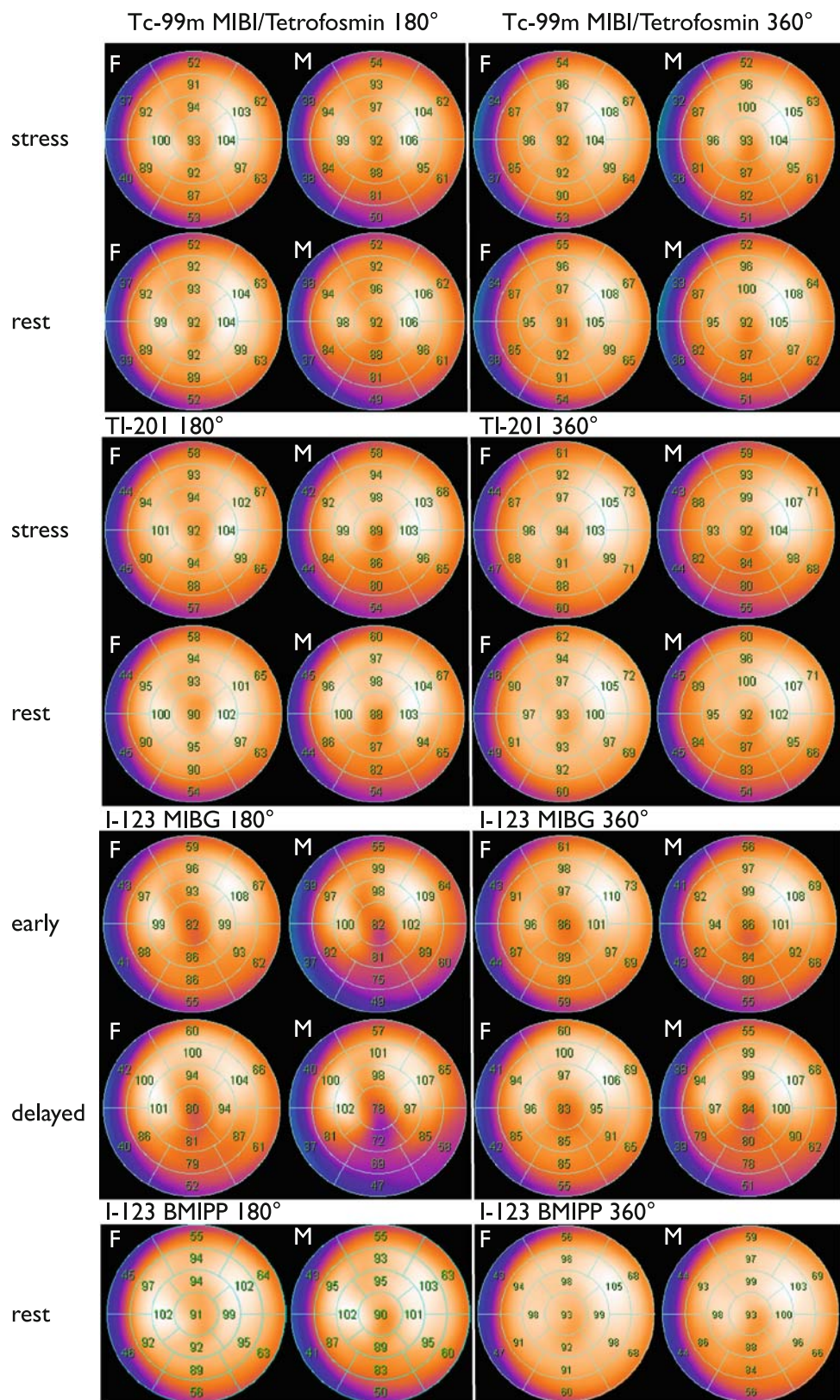
Fig. 1 Polar map presentation of normal myocardial SPECT databases using a 17-segment model. Average segmental values are overlaid on the maps. *Upper two panels* stress and rest perfusion studies with ^{99m}Tc-labeled tracers (MIBI and tetrofosmin) and ^{201}Tl using 180° and 360° acquisition methods. *Lower two panels* ^{123}I BMIPP and ^{123}I MIBG studies with 180° and 360° acquisition methods

A Scores of RCA region in male patients

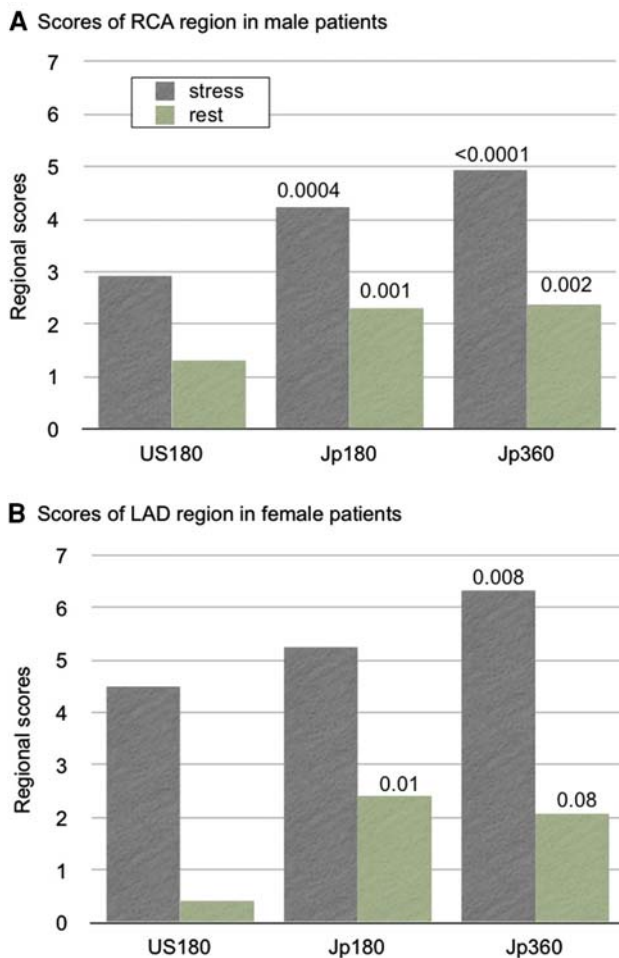**B** Scores of LAD region in female patients

Fig. 2 Regional summed stress scores determined by Japanese 180° and 360° databases (Jp180, Jp360) and an American 180° database (US180). The normal database was applied to a Japanese patient group ($n = 90$) with a 360° acquisition [7]. **a** Regional scores in the right coronary artery (RCA) territory in males. **b** Those in the left anterior descending coronary artery (LAD) territory in females. A *P* value in *each bar* is indicated in comparison with US180 database

Table 1 Normal values of left ventricular function by gated SPECT based on 16-frame gated SPECT with ^{99m}Tc-MIBI and tetrofosmin

JSNM WG database	Males	Females
Number of subjects	49	35
Age (years)		
Mean ± SD	58.3 ± 13.0	55.6 ± 13.7
EF (%)		
Mean ± SD	65.6 ± 5.9	71.0 ± 7.3
Mean − 2SD	53.8	56.4
Mean + 2SD	77.4	85.6
EDV (mL)		
Mean ± SD	82.3 ± 16.3	67.4 ± 13.1
Mean − 2SD	49.7	41.2
Mean + 2SD	114.9	93.6
ESV (mL)		
Mean ± SD	28.7 ± 9.0	20.1 ± 7.9
Mean − 2SD	10.7	4.3
Mean + 2SD	46.7	35.9
EDVI (mL/m^2)		
Mean ± SD	49.0 ± 8.0	42.3 ± 5.9
Mean − 2SD	33.0	30.5
Mean + 2SD	65.0	54.1
ESVI (mL/m^2)		
Mean ± SD	17.1 ± 4.8	12.6 ± 4.0
Mean − 2SD	7.5	4.6
Mean + 2SD	26.7	20.6
Small heart (ESV <20 mL)	22%	51%

JSNM WG Japanese Society of Nuclear Medicine Working Group, *EF* ejection fraction, *EDV* end-diastolic volume, *ESV* end-systolic volume, *EDVI* EDV index, *ESVI* ESV index

QGS software was evaluated well regarding inter-observer variability, the precision of EF and left ventricular volume determination was further confirmed in the multicenter J-ACCESS investigation [13, 14]. The reproducibility or precision of EF was good in 106 hospitals, showing a standard deviation of <3.6%, and the coefficient of variance of the end-diastolic volume was <9.3% in all cases. However, it has also been noticed that if American and European standard values are used, the normal values were not always appropriate for a Japanese population in clinical practice [15–18]. In fact, when a certain threshold value was used for discriminating abnormal patients or estimating cardiac event risks, it may have been potentially misleading for patient care. The normal values of left ventricular function calculated in a Japanese population are shown in Table 1, which are derived from the JSNM

working group study. The calculated EF value was higher for women than in men in Japanese populations for both JSNM database and J-ACCESS prognostic database (Table 2) [6, 19]. This is not simply because of underestimation of volume and overestimation of EF in small hearts due to an algorithm of edge tracing by QGS software [20, 21]. A magnetic resonance imaging (MRI) study also demonstrated that women had a higher left ventricular EF than men in the general population of Dallas County residents aged 30–65 years (1435 women, 1183 men) [22]. A low left ventricular EF was defined as below 61% in women and below 55% in men by MRI, and the difference between genders was comparable for our gated SPECT studies. In a Japanese population, mean female EF was higher when compared with that of American and European populations, which seemed to reflect smaller body size in Japanese women (Table 2). The lower borders of EF can be defined as below ∼55% in women and below ∼50% in men using gated SPECT.

The diastolic function determined for the Japanese population using a 16-frame format is summarized in

Table 2 Comparison of normal values of left ventricular function by QGS software

	Males			Females		
	Mean ± SD	Mean − 2SD	Mean + 2SD	Mean ± SD	Mean − 2SD	Mean + 2SD
De Bondt (43 M, 59 F) [16]						
EF (%)	59 ± 6	47	71	66 ± 9	48	84
EDV (mL)	106 ± 25	56	156	75 ± 23	29	121
ESV (mL)	44 ± 14	16	72	27 ± 14	−1	55
EDVI (mL/m^2)	54 ± 14	26	82	43 ± 11	21	65
ESVI (mL/m^2)	23 ± 8	7	39	16 ± 7	2	30
Ababneh (116 M, 124 F) [17]						
EF (%)	62 ± 7	48	76	67 ± 8	51	83
EDV (mL)	74 ± 22	30	118	57 ± 17	23	91
ESV (mL)	29 ± 13	3	55	19 ± 11	−3	41
EDVI (mL/m^2)	38 ± 9	20	56	32 ± 8	16	48
ESVI (mL/m^2)	15 ± 6	3	27	10 ± 5	0	20
J-ACCESS (119 M, 149 F) [14]						
EF (%)	63 ± 7	49	77	74 ± 9	56	92
EDV (mL)	88 ± 23	44	132	59 ± 17	25	93
ESV (mL)	33 ± 13	7	59	17 ± 10	−3	37
EDVI (mL/m^2)	51 ± 12	27	75	39 ± 11	17	61
ESVI (mL/m^2)	19 ± 7	5	33	11 ± 6	−1	23
JSNM WG (68 M and 68 F) [6][a]						
EF (%)	64 ± 7	50	78	69 ± 7	54	84
EDV (mL)	80 ± 16	49	112	64 ± 13	39	90
ESV (mL)	29 ± 9	12	47	20 ± 7	7	34
EDVI (mL/m^2)	47 ± 9	30	64	42 ± 7	29	55
ESVI (mL/m^2)	17 ± 5	8	27	13 ± 4	5	22

M males, *F* females

[a] Both data from 180° and 360° rotation acquisition methods are added

Table 3 using the JSNM database with two previously published studies [18, 23]. Although a 32-frame division of a cardiac cycle might provide better correlation with those determined by radionuclide ventriculography [24, 25], a more practical approach seems to be a 16-frame acquisition per RR interval, when considering the counting statistics of the myocardial activity. Using QGS software algorithm, abnormal thresholds in the American population included peak filling rate (PFR) <1.70 per s and time to PFR (TTPF) >208 ms [18]. Multivariable analysis showed that age, sex, EF and heart rate were strong predictors for PFR, whereas TTPF was not influenced by any clinical or systolic function variables. The Japanese population also showed comparable normal values (Table 3). When patients were classified into two age groups of <60 and ≥60 years, standard deviations of PFR, 1/3 mean filling rate, TTPF and TTPF/RR were larger in the older group than in the younger group. Because age-related differences were observed, it should be kept in mind that diastolic dysfunction in elderly patients and in those with EF < 50% are more common [26]. Large population-based criteria,

adjusted for age and sex, for normal versus abnormal diastolic function have not yet been established. Therefore, when the severity of diastolic dysfunction has become increasingly important in patients with the clinical syndrome of heart failure, the validity of diastolic function should be more extensively evaluated with nuclear methods [1].

To evaluate left ventricular regional wall motion, wall thickening seemed to be more appropriate for gated SPECT. When wall motion defined by endocardial perimeter was used (unit of mm), septal motion was relatively low when compared with that of free walls. The postoperative heart typically showed decreased motion even when septal systolic wall thickening (unit of %) was preserved [27–29]. Therefore, we recommend the use of thickening map for evaluating regional asynergy. Normal values of wall thickening were evaluated from a total of 202 patients in the JSNM database [30]. In any acquisition protocol, myocardial wall thickening in the apex was higher than that in the mid and basal regions. Different rotation angles showed no significant change on wall

Table 3 Normal values of diastolic parameters using 16-frame gated SPECT

	JSNM WG			Nakajima [23]	Akincioglu [18]
	All	<60 years	≥60 years	Control group	All
Number of subjects	60	33	27	16	90
Age (mean ± SD)	58 ± 15	48 ± 11	70 ± 6	50 ± 12	53 ± 11
Heart rate (per min) (mean ± SD)	66 ± 12	66 ± 11	65 ± 13	65 ± 7	74 ± 8
Peak filling rate (per s)					
Mean ± SD	2.69 ± 0.57	2.79 ± 0.53	2.58 ± 0.60	2.46 ± 0.45	2.62 ± 0.46
Mean − 2SD	1.55	1.73	1.38	1.56	1.70
Mean + 2SD	3.83	3.85	3.78	3.36	3.54
1/3 mean filling rate (per s)					
Mean ± SD	1.60 ± 0.39	1.68 ± 0.30	1.51 ± 0.47	1.52 ± 0.25	
Mean − 2SD	0.82	1.08	0.57	1.02	
Mean + 2SD	2.38	2.28	2.45	2.02	
Time to peak filling (ms)[a]					
Mean ± SD	167 ± 38	159 ± 26	176 ± 48	166 ± 22	165 ± 22
Mean − 2SD	91	108	80	122	121
Mean + 2SD	243	210	273	210	208
Time to peak filling/RR interval					
Mean ± SD	0.18 ± 0.03	0.17 ± 0.02	0.18 ± 0.04	0.18 ± 0.02	
Mean − 2SD	0.12	0.13	0.11	0.14	
Mean +2 SD	0.24	0.22	0.26	0.22	
Ejection fraction (%)					
Mean ± SD	68 ± 6	67 ± 7	69 ± 7	68 ± 9	64 ± 6

[a] Time to peak filling is defined as time from end systole to PFR

thickening, but different frame rates and tracers showed significant differences in both genders. The higher wall thickening in women than in men was comparable to findings of the higher EF in women. Because wall thickening has not been used separately depending on the acquisition protocol and gender differences so far, appropriate database construction might be required. Because wall thickening was relatively uniform in the six basal segments, six mid segments and four apical segments in each gender, practical threshold values are shown in Table 4 using 16-frame gated SPECT with both 360° and 180° acquisition methods added. For males, approximate lower borders of wall thickening are 30, 40 and 50% for mid, apical and apex segments, respectively. For females, they were 35, 45 and 55% for mid, apical and apex segments, respectively.

Normal database for I-123 BMIPP fatty acid imaging

In clinical practices in Japan, where BMIPP is approved by the Health, Labor and Welfare Ministry and covered by health insurance, normal myocardial ^{123}I-BMIPP databases

Table 4 Normal values of wall thickening (%) using 16-frame gated SPECT

	Males	Females
Number of subjects	36	33
Six basal segments		
Mean ± SD	24.7 ± 9.5	25.1 ± 9.4
Mean − 2SD	5.7	6.2
Mean + 2SD	43.8	43.9
Six mid segments		
Mean ± SD	47.2 ± 9.2	53.0 ± 9.1
Mean − 2SD	28.8	34.8
Mean + 2SD	65.5	71.3
Four apical segments		
Mean ± SD	62.6 ± 10.5	69.1 ± 11.3
Mean − 2SD	41.7	46.5
Mean + 2SD	83.5	91.7
An apex segment		
Mean ± SD	74.2 ± 12.1	77.5 ± 12.1
Mean − 2SD	50.0	53.4
Mean + 2SD	98.4	101.7

Both data from 180° and 360° rotation acquisition methods are added [30]

have not been defined and utilized. Japanese nuclear cardiology guidelines approved fatty acid imaging with respect to indications for acute coronary syndromes and repeated ischemic episodes in chronic syndromes [2, 31–33]. Common findings included perfusion and metabolic mismatch, suggesting temporary metabolic deterioration in the viable myocardium. The BMIPP accumulation reflected a risk area after acute myocardial infarction and perfusion defect reflected myocardial infarction [34]. Although comparison between perfusion and metabolism is essential, an appropriate normal database would contribute to enhanced diagnostic accuracy. Owing to small, but significant differences between ^{99m}Tc perfusion tracer and ^{123}I-BMIPP existed, the use of common databases would be helpful for accurate diagnosis [35]. In the ^{123}I-labeled tracer databases, only 360° datasets were available. As a result, 180° databases were made tentatively using a left anterior 180° arc of the whole rotation range (Fig. 1).

Normal database for I-123 MIBG sympathetic imaging

According to nuclear cardiology guidelines by the Japanese Circulation Society, ^{123}I-MIBG contains clinical indications for heart failure particularly for evaluating severity, therapeutic effects and prognosis of heart failure [2, 36–38]. Using MIBG uptake indices, a quantitative threshold for low risk of cardiac mortality and potentially fatal ventricular arrhythmias might be identified [39]. In addition, the MIBG study showed markedly decreased myocardial uptake in Parkinson's disease, dementia with Lewy bodies (DLB) and pure autonomic failure, which is a common feature of Lewy-body diseases [40–43]. In the report of the Consortium on DLB International Workshop, the MIBG study was included as one of the supportive features of DLB [44]. To quantify MIBG uptake, heart to mediastinal average count (H/M) ratio has been used as a simple method that could be used in any institutes [45]. However, lack of standardization hampers large-scale implementation of ^{123}I-MIBG parameters in the evaluation of patients with chronic heart failure [46, 47]. In particular, a choice of collimators was an important factor of quantitative variations. Thus, the JSNM database also aimed at creating a normal database for planar anterior images as well as SPECT imaging.

A number of MIBG studies have used the H/M ratio as a practical method for quantification. When low-energy collimators were used, the average H/M ratios were around 2.1–2.4, with the lower cutoff values around 1.6–2.0 [48]. In contrast, if medium-energy or low-medium-energy collimators were used, the average values were around 2.8–3.0. The H/M ratio accumulated from the JSNM working group is summarized in Table 5. According to a

Table 5 Normal values of I-123 MIBG heart to mediastinum ratio

	LE collimator	ME or LME collimator
JSNM WG data		
Number of patients	36	20
Early H/M ratio		
Mean ± SD	2.39 ± 0.21	2.76 ± 0.31
Mean − 2SD	1.97	2.14
Mean + 2SD	2.81	3.38
Delayed H/M ratio		
Mean ± SD	2.49 ± 0.25	3.01 ± 0.35
Mean − 2SD	1.99	2.31
Mean + 2SD	2.99	3.71
Questionnaire survey in Japan [47]		
Number of institution	15	2
Early H/M ratio		
Mean ± SD	2.25 ± 0.27	2.78 ± 0.32
Mean − 2SD	1.71	2.14
Mean + 2SD	2.79	3.42
Delayed H/M ratio		
Mean ± SD	2.36 ± 0.24	3.17 ± 0.29
Mean − 2SD	1.88	2.59
Mean + 2SD	2.84	3.75

LE low energy, *ME* medium energy, *LME* low-medium-energy, *H/M* heart to mediastinum

questionnaire survey conducted in Japan, normal H/M ratios using a low-energy high-resolution collimator and a medium-energy collimator were comparable to those of the JSNM database [49]. Significant differences were found between H/M values from data using both collimators. To standardize H/M ratios, some attempts have been presented, such as use of medium-energy collimators [50], deconvolution of septal penetration [51] and multiple-window or iodine-123 dual energy window (IDW) methods [48, 52]. When the IDW method was used with a calibration phantom and in clinical studies, corrected H/M values with a low-energy collimator became comparable to that of a medium-energy collimator. A method for stabilizing the location of the region of interest should also be investigated. Further studies are required to determine whether this type of correction can truly enhance diagnostic ability, and whether they may be used for multicenter studies.

Three-dimensional MIBG distribution seemed to be heterogeneous based on a SPECT study [53]. The sympathetic nervous system in the human left ventricle showed age- and gender-related regional changes [54]. In clinical practice, a decrease in MIBG uptake in the inferolateral walls has sometimes been observed particularly in elderly patients, but individual differences in segmental uptake have also been observed. In accordance with this finding,

myocardial MIBG databases showed relatively decreased activity in the inferior, which was more prominent in the delayed image (Fig. 1). The deviation of the apical inferior wall is relatively increased. Although it is conceivable that age-related changes influenced count distribution, we could not make age-specific standards because of the limited number of normal patients.

Cardiovascular event risk

Quantification of abnormal perfusion defect or induced ischemia serves to enhance diagnostic accuracy and patient risk stratification. For estimating patient prognosis, semi-quantitative evaluation of summed score of stress, rest and difference are powerful predictors of hard and all events, in addition to being factors of baseline left ventricular function. The evidence-based role of scoring has been employed for risk evaluation in patients suspected of having ischemic heart disease. The Japanese multicenter prognostic cohort study (J-ACCESS prognostic database) demonstrated that a stress myocardial perfusion study with gated SPECT could provide effective prognostic information, although the hard event rate was relatively lower in a Japanese population [55–57]. In fact, according to the governmental statistics, the mortality rate caused by cardiac diseases in Japan is one of the lowest in the world compared with that of American and European countries. The rate is about one-third that of the US. Nevertheless, normal and severely abnormal summed stress score values were associated with low (2.3%/3 years) and high (9.2%/3 years) rates of major cardiac events, including cardiac death, non-fatal myocardial infarction and severe heart failure. Rates of major cardiac events were significantly higher in patients with EF < 45% than in those with EF ≥ 45% (16.6 vs. 2.9%/3 years; $P < 0.001$). Although a precise description for the event risk is not the aim of this article, risk evaluation based on the Japanese databases and ethnic background would be essential for effective patient management.

Future directions

The characteristics of normal databases depend on technological advances in SPECT. Several attempts have been performed to improve attenuation, scatter and resolution corrections [58, 59]. Attenuation correction might enable the use of a single gender-independent normal database and a single criterion for abnormality. However, attenuation correction seems to provide different effects based on the imaging system used [60]. The prone positioning was also used to compensate for attenuation artifacts [61, 62]. Attenuation correction of myocardial SPECT by

scatter-photopeak window method was also investigated [63]. Because myocardial count distribution in normal subjects does not show complete homogeneity with any methods, some kind of additional database matched with advanced technological capability would be required. Moreover, a validation study to determine appropriate cutoff values between normal and abnormal groups should be investigated. With the recent advances of fusion technology using X-ray computed tomography angiography and myocardial perfusion imaging, functional relevance to coronary stenosis could be enhanced [64–66]. Quantitative accuracy would be further improved by anatomical and functional correlations using appropriate normal databases.

Conclusions

The JSNM normal databases were the first databases authorized by the scientific society. The mixture of typical acquisition condition from different institutions has merits for applying the same database to a multicenter study and to inter-institution comparison of the SPECT results. Although an institution-specific database created in every institution would be theoretically desirable, a common database could be a practical approach for clinical evaluation of patients suspected of having coronary artery diseases. Finally, normal values derived from a common database could be applied in clinical studies with respect to myocardial perfusion, left ventricular systolic and diastolic function, fatty acid imaging and sympathetic imaging.

Appendix

Participating hospitals and researchers for database accumulation

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Cooperation for creating normal databases

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Cooperating companies

GE Yokogawa Medical Systems (Tokyo, Japan), Toshiba Medical Systems Corporation (Tokyo, Japan), Siemens-Asahi Medical Technologies (Tokyo, Japan), Hitachi Medical Corporation (Tokyo, Japan), Shimadzu Corporation (Kyoto, Japan), FUJIFILM RI Pharma (Tokyo, Japan), Nihon Medi-Physics (Tokyo, Japan).

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