Myocardial Perfusion SPECT and ATTR imaging 2021 in Germany: Results of the 9th Survey

Myokard-Perfusions-SPECT 2021 in Deutschland: Ergebnisse der 9. Erhebung

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ABSTRACT

Aim This paper presents the results of the 9th survey of myocardial perfusion SPECT (MPS) from the reporting year 2021.
Methods 218 questionnaires (131 practices (PR), 58 hospitals (HO), 29 university hospitals (UH)) were evaluated. Results of the last survey 2018 are set in squared brackets.
Results MPS data from a total of 133,057 [145,930] patients (–8.8 %) with 131,868 [143,707] stress and 106,546 [121,899] rest MPS were analysed. A comparison with official data revealed that 54 % all MPS were recorded. From 2018 to 2021, official data showed a every year an increase in MPS numbers. On average, 610 [502] MPS patients (+ 22 %) were examined in each department. 74 % [69 %] of the responders reported an increase or no changes in their MPS patient numbers. Ambulatory care cardiologists represented as always, the mayor referral group (68 % [69 %]). For the first time, pharmacological stress was more frequently applied than ergometry (42 % [51]). Regadenoson was mostly used. The use of the different protocols remained nearly unchanged. Two-day protocols were predominantly applied (49 % [48 %]). A shift from multi-headed cameras (58 % [72 %]) to SPECT-CT systems (24 % [17 %]) was found. Attenuation correction was performed in 33 % [26 %] of all MPS. 88 % [86 %] of all stress, 88 % [87 %] of all rest and 87 % [83 %] of all stress and rest MPS were acquired as gated SPECT. 72 % [67 %] of all departments performed scoring by default. The number of departments without scoring decreased to 13 % [16 %].
Conclusions The MPS Study 2021 shows that the long-term positive development of MPS imaging in Germany is continuing. The COVID-19 pandemia did not change this trend. The procedural and technical details of MPS imaging reveal a high level of guideline conformity.

Introduction

Since 2006, the working group Cardiovascular Nuclear Medicine of the German Society of Nuclear Medicine has performed regular surveys to obtain information on technique, utilisation and development of myocardial perfusion SPECT (MPS). The first surveys were conducted annually [1, 2, 3, 4, 5]. Since 2009, the survey has been carried out every 3 years [6, 7, 8]. Compiled data from 2012 to 2021 have been published recently [9].

In this paper, the data from the last survey are presented in detail with regard to the different types of department (practices, hospitals, university hospitals) and regional distribution. In addition, data of imaging in cardiac amyloidosis are presented for the first time.

Due to the COVID-19 pandemia, at least temporarily, declining examination numbers were recorded in all fields of nuclear medicine in Germany in 2020. In the field of MPS imaging from 2019 to 2020 a decline by 1.4 % was found [10]. The current survey for the reporting year 2021 also provides information about long-term effects of the pandemia on nuclear cardiology imaging.

Methods

The updated database from the 2018 survey was used to contact departments and physicians practicing nuclear medicine in Germany. A one-page questionnaire with a cover letter was sent by fax in mid-January 2022. In case of no feedback, a first reminder was sent 4 weeks later, and a second 4 to 6 weeks after that, in some cases after personal contact. The survey was closed at the end of May 2022.

The one-page questionnaire comprised the items:

- number of MPS patients,
- number of stress and rest MPS procedures,
- number of different types of stress test,
- number of patients by study protocol,
- percentage of patients examined with gated SPECT,
- percentage of patients examined with attenuation correction,
- type of attenuation correction,
- usage of semiquantitative scoring (categories: never, intermediate, always),
- type of camera,
- percent referrals from cardiologists, primary care physicians, from in-patient ward physicians, and others,
- changes in referral (categories: no change, unchanged, more, unknown) and in case of a decline potential causes (stress-echocardiography, cardiac CT, cardiac MRI, invasive coronary angiography (ICA), COVID-19 pandemia),
- number of bone scans for diagnosing cardiac amyloidosis, and estimated positive rate.

To verify the representativeness of the survey and to reliably estimate the total or MPS numbers in Germany in 2021, the survey figures obtained were related to the data of the National Association of Statutory Health Insurance Physicians (NASHIP) (Kassenärztliche Bundesvereinigung (KBV)). The share of privately insured persons was set to 11.2 % based on the 2019 microcensus survey [11]. The NASHIP data were communicated in July 2022 following an official written request by the DGN (German Society of Nuclear Medicine).

Furthermore, the MPS counts were related to the ICA (invasive coronary angiography) and intervention data of the most recent German cardiology report (Deutscher Herzbericht) [12]. The data of this report refer to the year 2020, but no ICA data by federal state were given. Thus, a regional relation to MPS, as performed in former publications was not possible.

Results

Practices are abbreviated as PR, hospitals as HO and university hospitals as UH. For comparison, the previous survey data (reporting year 2018) are set in square brackets.

Medical supply centres (Medizinische Untersuchungszentren, MVZ) were assigned to practices, as they are part of ambulatory medical care.

Questionnaires were sent to nuclear medicine and radiology departments performing some form of nuclear medicine. Feedback was given in 278 [251] cases. Of these, 60 [33] reported that no MPS were performed in 2021 or at all.

Thus, questionnaires from 218 [291] departments were analysed: 131 [173] PR, of these 14 [19] medical supply centres, 58 [77] HO, and 29 [30] UH.

36 [93] departments not participating in the past survey submitted data this time, whereas 86 [60] departments from the 2018 survey failed to return data.

MPS numbers and regional distribution

MPS data from a total of 133,057 [145,930] patients (–8.8 %) with 131,868 [143,707] stress and 106,546 [121,899] rest MPS were recorded.

71 % [76 %] of all patients were studied in PR, 18 % [16 %] in HO and 11 % [8 %] in UH. On average, 610 [502] MPS patients (+ 22 %) were examined in each department (PR 723 [604] + 19,7 %, HO 417 [296] + 40 %, UH 487 [400] + 21,8 %).

The median MPS count was 392 [278], in PR 429 [311], in HO 259 [171] and in UH 422 [258.5]. In all department types the median was clearly below the mean value, indicating a greater proportion of departments with low MPS examinations. The patient count ranged from 2 to 5613 [3 to 5200] in PR, from 1 to 2100 [3 to 2400] in HO, and from 3 to 2191 [6 to 1297] in UH.

The numbers of patients by federal state are compiled in ▶ **Table 1** and illustrated in ▶ **Fig. 1**.

From 2018 to 2020 (at the time of writing this paper no more recent data were available), the number of invasive coronary angiographies (ICA) decreased by 7.8 % from 867,138 to 798,751. The ICA/MPS ratio declined from 4.0 to 3.2 (MPS data from 2021).

NASHIP count

The 2021 data of the National Association of Statutory Health Insurance Physicians (NASHIP, Kassenärztliche Bundesvereinigung) reported a frequency of 189,649 [163,272] examinations for the fee schedule item 17330 (stress MPS) and of 158,080 [136,585] for the item 17331 (rest MPS). The time course of both items from 2006 onwards is illustrated in ▶ **Fig. 2**.

Based on the NASHIP data, a 11.2 % proportion of privately insured patients [11] and the referral structure, 54 % of all MPS were included in the 2021 survey.

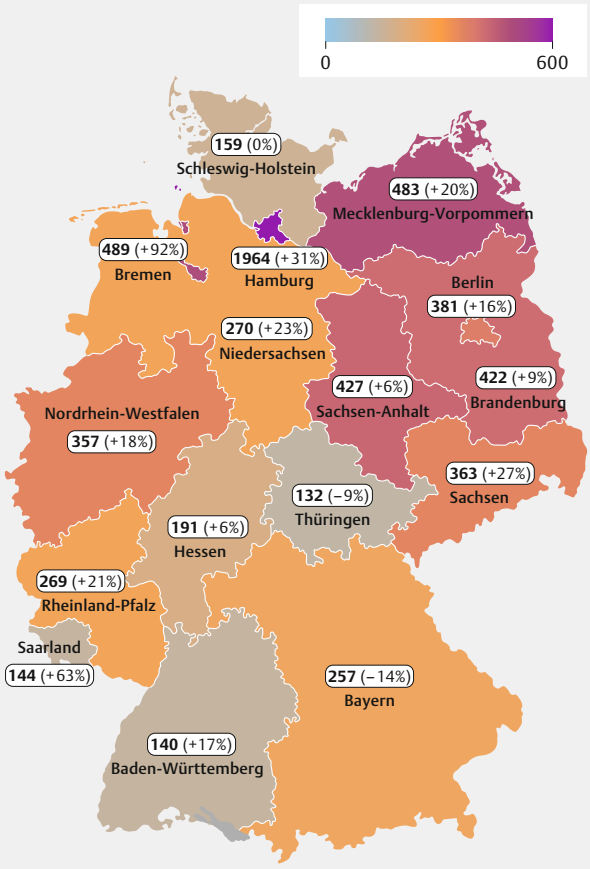
Changes in MPS numbers from 2018 to 2021

One hundred and eighty-one departments (109 PR, 46 HO, 26 UH) participated in both the 2018 and the 2021 survey. In these, the MPS count increased by 15.7 %. The largest increase was reported from hospitals (PR 15 %, HO 20 %, UH 18 %).

▶ **Table 1** Myocardial perfusion SPECT and invasive coronary angiographies per 100,000 inhabitants by federal states in 2021.

Federal state	No of responding departments	MPS, patients per 100,000
Baden-Württemberg	19 [33]	140 [119]
Bayern	25 [43]	257 [298]
Berlin	11 [14]	381 [327]
Brandenburg	8 [8]	422 [388]
Bremen	3 [3]	489 [254]
Hamburg	4 [7]	1056 [808]
Hessen	13 [16]	191 [181]
Mecklenburg-Vorpommern	7 [9]	483 [402]
Niedersachsen	23 [29]	270 [219]
Nordrhein-Westfalen	62 [74]	357 [302]
Rheinland-Pfalz	12 [17]	369 [222]
Saarland	4 [5]	144 [88]
Sachsen	8 [8]	363 [285]
Sachsen-Anhalt	5 [7]	427 [402]
Schleswig-Holstein	7 [9]	159 [159]
Thüringen	7 [9]	132 [146]
Germany	**291 [291]**	**296 [263]**

In square brackets: 2018 data.



▶ **Fig. 1** Myocardial perfusion SPECT per 100,000 inhabitants by federal states in 2021. In brackets: changes from 2018 to 2021.

▶ **Fig. 2** MPS counts of the National Association of Statutory Health Insurance Physicians (Kassenärztliche Bundesvereinigung) for the fee scale items (EBM) 17300 (stress) and 17331 (rest) from 2006 to 2021.

MPS referrers

▶ **Table 2** shows the referrer structure to MPS which remained nearly unchanged. Ambulatory care cardiologists continued to represent the major referral group (68 % [69 %]) in all kind of departments. The referral structure from 2006 to 2021 is depicted in ▶ **Fig. 3**.

Changes in MPS referral from 2018 to 2021 and competitive methods

74 % [69 %] of the participating departments reported an increase or no changes in their MPS patient numbers. This number was similar across all types of departments. Detailed data are compiled in ▶ **Table 3**.

9 % [14 %] observed a decrease in their MPS counts. In this small group (n = 21) the decrease was related to MRI in 14 % [15 %], to invasive angiography in 0 % [10 %], to stress echocardiography in 5 % [2 %], to CT in 10 % [2 %], and to more than one modality in 33 % [22 %]. The COVID-19 pandemia was only mentioned in 19 % (n = 4). The others (19 % [49 %]) did not give any reasons for the observed decline.

Stress tests

▶ **Table 4** lists the frequencies of the different stress modalities in MPS. ▶ **Fig. 4** shows the course from 2006 onwards.

Ergometry as the most frequent stress test has been replaced in all types of departments by pharmacological stress (42 % [51]). Regadenoson was the most frequently used pharmacological stress agent, with the highest amount in UH. Its share increased from 26 % to 35 %. The adenosine proportion remained constant (23 % [23 %]). Dipyridamole was no longer queried in 2021. Dobutamine as a 2nd

▶ **Table 2** Referrals to myocardial perfusion SPECT in 2021.

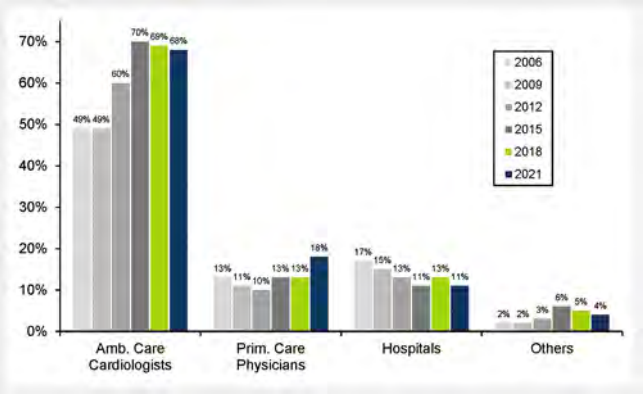
Referrer	Total [%]	Practices [%]	Hospitals [%]	University hospitals [%]
Ambulatory Care Cardiologist	68 [69]	75 [77]	57 [44]	38 [47]
Primary Care Physician	18 [13]	18 [13]	15 [15]	18 [9]
Hospital	11 [13]	3 [5]	24 [39]	39 [40]
Others	4 [5]	4 [5]	5 [3]	5 [4]

The figures refer to the total number of patients in the respective type of institution. In square brackets: 2018 data

▶ **Table 3** Changes in referral to myocardial perfusion SPECT from 2018 to 2022.

	Total [%]	Practices [%]	Hospitals [%]	University hospitals [%]
Increase	33 [36]	33 [37]	28 [37]	45 [33]
No change	41 [33]	40 [35]	50 [35]	28 [23]
Decrease	9 [14]	7 [12]	15 [14]	17 [17]
Unknown	17 [17]	20 [16]	7 [14]	3 [27]

In square brackets: 2018 data



▶ **Fig. 3** Referrer structure to MPS from 2006 to 2021. Internists were surveyed only up to 2012 (19 % in 2006; 23 % in 2009; 14 % in 2012).

choice stress agent was used in very rare cases irrespective of the type of department (0.1 %, 172 patients [0.3 %, 501 patients]).

Protocols

The use of the different MPS study protocols is given in ▶ **Table 5** and in ▶ **Fig. 5** from 2006 to 2021. In 2021, about 99.93 % [99.96 %] of all MPS were performed with Tc-99 m radiopharmaceuticals. Tl-201 was used in a few departments (5 [10]) mostly for viability imaging. No department applied Tl-201 exclusively for MPS imaging.

Patients were predominantly examined with two-day protocols (49 % [48 %]). The percentage of 1-day protocols changed from 34 % to 31 % and of stress-only imaging from 16 % to 21 %. UH had the highest 1-day protocol proportion (UH 52 % [71 %]), but also the highest stress-only proportion (20 % [16 %]).

Rest-only protocols were used very rarely (0.9 % [2 %]).

Camera systems

Data are listed in ▶ **Table 6**. In MPS imaging a few departments (3 % [5 %]) still work with a one-head camera. They examined only 1.2 % of all patients.

From 2018 to 2021, a shift from multi-headed cameras to SPECT-CT systems could be observed. 59 % of the UH had SPECT-CT cameras, but only a small proportion of the PR.

CZT systems were used in 7 % of the departments. The number of CZT patients slightly decreased from 26,150 in 2018 to 24,133 in 2021.

Only a very few used more than one camera system for MPS imaging.

Attenuation correction

In 2021, attenuation correction was performed in 33 % [26 %] of all MPS (22 % [17 %] of MPS in PR, 50 % [49 %] of MPS in HO, 74 % [61 %] of MPS in UH). 17 [30] departments applied supine/prone imaging for attenuation correction, 2 [10] used transmission sources and 65 [59] CT-based systems. 2 [1] departments had more than one system available.

▶ **Table 4** Type of stress test in 2021.

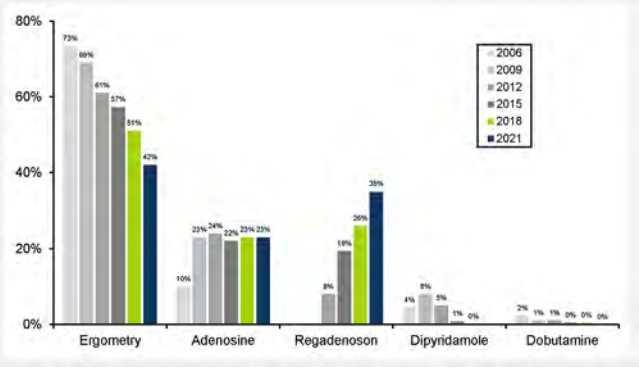
Stress test	Total [%]	Practice [%]	Hospitals [%]	University hospitals [%]
Ergometry	42 [51]	46 [56]	30 [36]	33 [33]
Adenosine	23 [23]	19 [19]	38 [35]	28 [31]
Regadenoson	35 [26]	35 [25]	32 [26]	39 [36]
Dipyridamole	–[1]	–[0*]	–[1]	–[0*]
Dobutamine	0* [0*]	0* [0*]	0* [2]	0* [0*]

In square brackets: 2018 data
*numbers < 0.5 and thus rounded to 0.

▶ **Table 5** Study protocols in 2021.

Protocol	Total [%]	Practices [%]	Hospitals [%]	University hospitals [%]
Tc-99 m MIBI/Tetro-fosmin stress and rest (1-day protocol)	31 [34]	28 [30]	26 [38]	52 [71]
Tc-99 m MIBI/Tetro-fosmin stress and rest (2-day protocol)	49 [48]	52[53]	55 [40]	15 [13]
Tc-99 m MIBI/Tetro-fosmin stress only	20 [16]	19 [17]	17 [19]	29 [12]
Tc-99 m MIBI/Tetro-fosmin rest only	0.9 [2]	0.3 [1]	2 [3]	3 [4]
Tl-201	0.07 [0.04]	0 [0.02]	0.06 [0.29]	0.18 [0.19]

The figures refer to the total number of MPS in the respective type of department. In square brackets: 2018 data



▶ **Fig. 4** Type of stress for myocardial perfusion SPECT from 2006 to 2021.

Gated SPECT and scoring

Data are given in ▶ **Table 7** and depicted in ▶ **Fig. 6** from 2006 onwards. Gated SPECT as the functional adjunct to myocardial perfusion SPECT showed a mild increase. In 2021, 88 % [86 %] of all stress, 88 % [87 %] of all rest and 87 % [83 %] of all stress and rest MPS were acquired as gated SPECT. In UH and HO nearly all MPS were performed as gated SPECT, followed by PR. Only 15 (6.9 %) [28 (9.6 %)] of the responding departments performed no gated SPECT at all.

The percentages of departments performing a regular, an intermediate, or no scoring are listed in ▶ **Table 8**. In 2021, 72 % [67 %] of all departments performed MPS scoring by default with the highest acceptance in HO. The number of departments without scoring decreased to 13 % [16 %] and with intermediate scoring to 15 % [17 %]. Interestingly, in UH the proportion performing a regular scoring decreased and of those not scoring increased. In absolute numbers these were 4 UH [2018 n = 3]. In the 13 % of departments not scoring only patients (6.4 % [8.6 %]) were examined.

Imaging for ATTR amyloidosis

Bone scintigrams for suspected ATTR amyloidosis were performed in 2,947 patients (PR 31 %, HO 24 %, UH 45 %) (▶ **Fig. 7**). The proportion of positive findings was 37 % and ranged from 31 % in UH, 38 % in HO to 42 % in PR.

Discussion

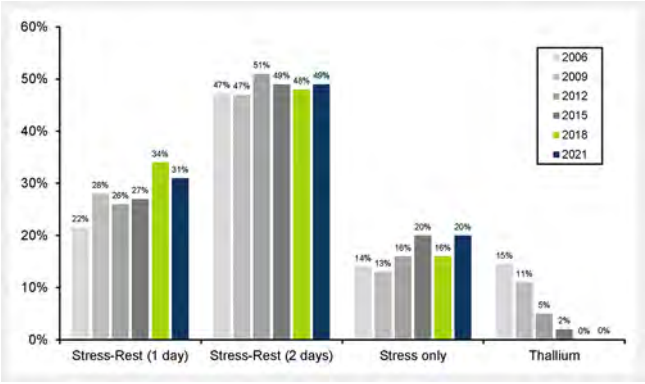
This paper presents the results of the 9th German MPS survey. Survey data from the reporting years 2005 to 2009, 2012, 2015,

and 2018 have been published [13, 14, 1, 2, 3, 4, 5, 6]. The number of returns was lower than in the 2018 survey. This also affected the reported MPS figures but to a lesser extent as MPS studies per department increased.

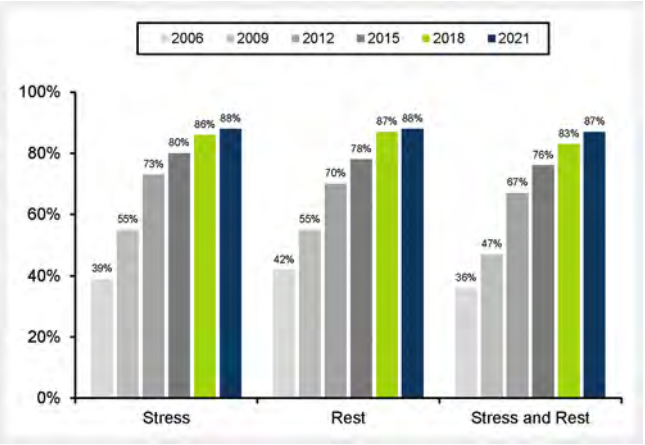
A comparison with the official NASHIP data showed that the current survey nevertheless covered more than 50 % of all MPS and that the results can be considered representative.

The key statements of MPS imaging in Germany in 2021 and thus the current status quo can be summarised as follows

The positive trend observed since 2012 continued. This is confirmed by the official NASHIP data and the respective assessments of the participating centres. Irrespective of the type of department, more than 70 % recorded stable or increasing examination



▶ **Fig. 5** Protocols for myocardial perfusion SPECT from 2006 to 2021. The difference to 100 % represents the small proportion of rest-only protocols not shown in this figure.



▶ **Fig. 6** Use of gated SPECT in myocardial perfusion SPECT from 2006 to 2021.

▶ **Table 6** Camera systems for MPS imaging.

	Total [%]	Practices [%]	Hospitals [%]	University hospitals [%]
One-head camera	3 [5]	3 [5]	4 [5]	0 [0]
Multi-head camera	59 [71]	71 [78]	54 [72]	21 [33]
SPECT-CT	12 [18]	12 [10]	35 [23]	59 [47]
Dedicated cardiac camera	6 [5]	6 [6]	0 [0]	3 [17]
CZT*	7	10	4	10
More than one camera	3 [1]	7 [1]	3 [0]	7 [3]

In square brackets: data from the 2018 survey.
*CZT was first specifically requested in 2021. Before, it was subsumed under dedicated cardiac camera

▶ **Table 7** Myocardial perfusion SPECT performed as gated SPECT in 2021.

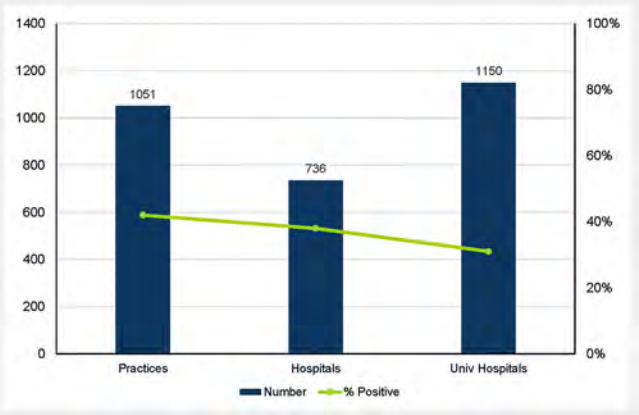
	Total [%]	Practices [%]	Hospitals [%]	University hospitals [%]
Stress study as gated SPECT	89 [86]	86 [84]	95 [85]	99 [96]
Rest study as gated SPECT	88 [87]	84 [82]	96 [96]	99 [98]
Stress and rest study as gated SPECT	87 [83]	84 [80]	95 [85]	99 [96]

In square brackets: data from the 2018 survey.

▶ **Table 8** Utilization of perfusion scores in 2021 by institution.

Frequency	Total [%]	Practices [%]	Hospitals [%]	University hospitals [%]
regular	72 [67]	61 [62]	74 [65]	69 [76]
intermediate	15 [17]	23 [24]	16 [17]	10 [14]
never	13 [16]	16 [14]	10 [18]	21 [10]

In square brackets: data from the 2018 survey.



▶ **Fig. 7** Bone scintigrams for ATTR diagnosis and rate of positive findings.

numbers, and only 9 % (n = 21) a decline. The supposed cause of the decline cannot be clearly attributed to a specific imaging modality, but rather to the totality of competing imaging modalities. Due to the low number of departments with declining examinations a splitting by PR, HO, UH was not performed.

In only one fifth (n = 4) of these departments was the COVID-19 pandemia regarded as the cause. Since these were only a few departments, it explains why there was no effect on the overall MPS trend. This is confirmed by the NASHIP data, which show a at least a small increase, but no drop in the first pandemic year 2020, and a compensation in 2021.

Some studies found that the number of nuclear medicine procedures, as well as MPS examinations decreased (sometimes dramatically) in 2020 during the first COVID-19 lockdown [15, 16, 17, 18]. In Germany, a web-based questionnaire with 91 responses found a 1.4 % decrease in MPS imaging in 2020 compared to 2019 [10]. It can be assumed that departments with declining numbers were more likely to respond to this query.

From 2018 to 2021, the estimated ICA/MPS ratio decreased from 4.0 to 3.2. The value indicates that invasive procedures were performed at least three times more often than non-invasive procedures, a ratio that should be reversed according to the current guideline [19].

It is unlikely that the ICA/MPS ratio will significantly change if the other non-invasive imaging procedures are added. Figures on the use of stress echocardiography, cardiac MRI and CT are generally rare in Germany.

However, cardiac CT and MRI data from 2019 are available. In this survey 69,286 cardiac CT and 64,281 cardiac MRI were registered. A subdivision by type of examination was not performed [20]. Therefore, the number of cardiac CT and MRI examinations for diagnosing Chronic Coronary Syndrome (CCS) is unknown. It is obvious that the proportion is low. Therefore, the ICA/cardiac imaging ratio is expected to be close to the range of the ICA/MPS ratio.

The low numbers of the other imaging modalities explain the only slight shift from MPS examinations to other cardiac imaging and confirm that MPS remains the leading modality for the non-invasive diagnosis of CCS. Accordingly, cardiologists represent the largest referral group over the years.

Several issues indicate an ongoing improvement in MPS quality

- The average number of MPS examinations per department has increased in all department types, especially in hospitals. This trend has been observed for several years and is a positive development as expertise and quality parallel the number of examinations.
- The camera systems used for MPS imaging are at a high level. Only 3 % of the departments still acquire MPS with single-head cameras. They are low-end users, accounting for only 1.2 % of the studies. The others used multi-head cameras with a growing proportion of SPECT-CT systems. The increase in examinations with SPECT-CT is encouraging as more studies are performed with attenuation correction (AC), which improves specificity [21]. In 2021 one third of all MPS were performed with AC. The proportion was highest in UH, followed by HO and PR. It is likely that the trend towards more AC will continue in the future as more cameras are replaced by SPECT-CT systems.
- Departments with CZT systems are high-end users. However, the total number of MPS examinations with CZT systems remained nearly unchanged.
- Gated SPECT again increased slightly and exceeded the 85 % mark. Based on 2006, when only about 40 % of all MPS were performed as gated SPECT, this is a favorable development.
- MPS scoring continues to show increasing acceptance. Only 13 % of the responding departments, with underproportional MPS numbers, did not apply this feature despite clear guideline

recommendations [13, 22]. This issue remains a weakness and the objective of further training.

- In 2021, for the first time, more pharmacological stress than exercise stress was performed. Regadenoson has become the leading pharmacological stressor, with adenosine remaining at a level of 23 %. Dobutamine, as the second-choice pharmacological stress agent, was only applied in very rare settings, indicating that nearly all patients could be stressed with exercise or vasodilators. ▶ **Fig. 4** shows that the decline in ergometry was greatest from 2018 to 2021. Two causes can be considered: One is the switch to pharmacological stress due to the COVID-19 pandemia, the other is more referrals of patients with comorbidities and limitations for ergometry.

Issues indicating a reasonable use of procedural radiation dose in MPS imaging

- More than 99.9 % of all MPS were further performed with Tc-99 m radiopharmaceuticals. Tl-201 is mostly used for viability imaging.
- Two-day protocols which require smaller doses of radioactivity than 1-day protocols are most frequently applied.
- The proportion of stress-only protocols (lowest radiation dose) is within the variations of the past surveys. A fact of every day MPS imaging is that patients are older and multimorbid. Thus, stress-only examinations due to a normal scan are not expected to increase significantly in the future.

Amyloid imaging

Bone scintigraphy for ATTR amyloidosis was queried for the first time in this survey. Given about 350,000 annual bone scans, the number of 2,947 ATTR bone scans is small (< 1 %) [23]. Interestingly, the results are positive in 31–42 %, indicating a good pre-selection. Subsequent surveys will show how imaging numbers will develop in this particular field.

The number of “regular” bone scans with suspected ATTR amyloidosis is unknown. A proportion of 0.36 % has been found in a large study with 12,400 “regular” bone scans [24]. Therefore, about 1.200 patients with suspected ATTR amyloidosis by “regular” bone scan as an incidental finding are to be expected in Germany every year. This number is within the range of positive patients in targeted ATTR bone scans.

Conclusion

The MPS survey 2021 shows that, the long-term positive development of MPS imaging in Germany has continued further. The COVID-19 pandemia did not change this trend. Procedural and technical details of MPS imaging show a high level of guideline conformity. Only in a few departments is there a need for additional training.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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