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AN INTERNATIONAL SURVEY ON CLINICAL REPORTING OF DUAL-MODALITY PET/CT IMAGING EXAMINATIONS: A STARTING POINT FOR CROSS-SPECIALTY ENGAGEMENT

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ABSTRACT.

Introduction. Combined PET/CT imaging has become an integral part of patient management, particularly in oncology. Following the imaging examination, a report of the findings is created by the expert readers and sent to the referrers as a basis for subsequent management decision-making for their patients. In view of the known wide variation in operational models of PET/CT imaging, we initiated a survey of PET/CT users regarding their approaches towards PET/CT reporting.

Materials and Methods. An electronic survey was composed with a set of 28 questions regarding the demographics and professional background of the survey responders, as well as questions regarding the structure and quality of PET/CT reports, including the type of reported information, the use of reporting standards and the mix of reporting and presenting experts. The survey was active during six weeks in early 2018. A total of 242 responses were collected worldwide.

Results. The responders were mainly from Europe (78%), Of all responders, 21% were nuclear medicine specialists, 41% were radiologists, 22% were dual-board certified, 9% were residents in either nuclear medicine or radiology, and 5% were medical physicists, radiographers or oncologists. A slim majority (55%) of responses indicated reports being done according to the EANM/SNMMI 2015 guidelines for ^{18}F-FDG-PET/CT imaging but 30% responders were unaware of these guidelines. Report structures varied across sites with most sites (38%) reporting the PET with supplementary localization information from CT, while 27% sites report along the lines of a CT report with supplementary PET information. One third of the reports include information on the TNM stage of the oncology patient in all reports, while 34% and 12% reports include this information occasionally or only for selected tumors, respectively. In case of therapy response assessment, various well-established criteria are employed ranging from 15% (EORTC) to 57% (Deauville) of cases.

Conclusions. Broad variation in the PET/CT reporting strategies adopted for oncology studies and widespread lack of awareness of existing guidelines for PET/CT reporting are evident from responses to this survey, raising concerns as to whether reporting clinicians are optimally utilizing the complementary information from each modality. Greater efforts are needed to ensure harmonization of reporting practices.

INTRODUCTION

Hybrid imaging methods (*1*), i.e. combinations of complementary anatomical and molecular imaging modalities (PET/CT, SPECT/CT and PET/MR) have been shown to add significantly to the standard diagnostic work-up of patients by both reducing the acquisition time of the examination and increasing the diagnostic accuracy over that of stand-alone imaging (*2,3*). While evidence is available supporting these advantages from numerous clinical research studies, it is important that this benefit is translated into routine clinical practice. The key vehicle for imaging data to be communicated to referring clinicians and efficiently integrated into decision-making is the scan report. The value chain of patient management, which includes imaging and reporting, can be described in general terms as follows: Patient > Attending physician > Clinical indication > Imaging test > Expert reviewing and reporting > Attending physician > Treatment decision and treatment > Follow-up (incl. imaging) > etc. (*4*). It is obvious that an imaging report (quality, timeliness, communication path) influences patient management directly (*5*).

Oncologists who refer their patients for a diagnostic work-up with hybrid imaging expect to gain insight not only into the presence of disease but also into its extent and biological characteristics, as a predictor of disease behaviour or baseline for assessment of response to treatment. To meet the expectations of referring clinicians, the ultimate product of a high-quality imaging examination should always be a high-quality report that is focussed on patient-important parameters with a conclusion aligned to questions pertinent to patient management. In contrast to a range of scientific efforts to optimize hybrid imaging protocols and procedures, to date, comparatively little attention has been given to the quality of the reporting of hybrid imaging examinations. This is despite the early efforts to standardize and harmonize hybrid imaging procedures that explicitly include consensus recommendations on the reporting procedures (*6, 7-9*). Recently, some emphasis has been given to clinical reporting in the context of employing report structures (*10*), which may soon become the focus of attention for a new culture of reporting (*11*).

Despite the importance of the diagnostic imaging report, it is frequently “created with free-style conventional dictation, leading to non-standardized, error prone, vague, incomplete, or untimely delivery of findings with significant interobserver variability.” (*12*). Moreover, past studies as well as our own experience show that PET/CT reports, in particular, can vary widely in quality and format, thus, potentially leading to misinterpretation and, ultimately, to

incorrect patient management (*13*). Part of the variation in reporting quality and culture may arise from variations in local and professional training programmes and backgrounds.

Hybrid imaging modalities, such as PET/CT, stand out from the range of typical radiological or nuclear medicine imaging examinations. Despite their potential to make use of synergistic and complementary diagnostic information, existing ownership and training schemes impact on the performance of such investigations (*14*). In light of a growing base of hybrid imaging systems and the potential to increase diagnostic accuracy from combined, “anato-metabolic imaging” (*15*), we intended to probe the current status of PET/CT reporting in the context of oncology patient management. Our key objective was to assess typical reporting regimens in routine clinical use world-wide and to probe the level of standardization and integration of imaging findings with other clinical factors.

MATERIALS AND METHODS

A web-based questionnaire was formulated by two imaging experts, each with over 20 y of experience in PET/CT. Questions were related to *demographics* (e.g., origin of survey responders, their age, gender, and nature of PET/CT operations in their practice) and *reporting culture* (e.g., structure of reports, content, dissemination). In addition, addressees were invited to provide *anonymized examples* of clinical PET/CT reports.

All questions were formulated in English and placed in Google Documents. The list of questions is seen in **Appendix 1**. An invitation to participate in this survey was sent out through the European Society of Hybrid, Molecular and Translational Imaging (ESHI-MT) on Apr-10, 2018 to the database of registered members. This society includes membership of North American radiologists of approximately 5%. Further, to increase potential responses the USA, a feature article in AuntMinnie on May-2, 2018 provided readers with a link to the survey [https://www.auntminnieeurope.com/index.aspx?sec=sup&sub=mol&pag=dis&ItemID=615893]. In addition, an invitation to partake in the survey (in German) was sent to the members of the German Working Group "Hybrid Imaging", a joint venture between the German Societies of Nuclear Medicine (DGN) and Radiology (DRG) on Apr-26, 2018. Two reminders were sent through the ESHI-MT distribution list. The survey was closed on May-28, 2018, thus, running for six weeks.

All responses were checked for completeness and collected in an Excel table. Free text responses (**Appendix 1:** questions 8, 12, and 23) were collected separately. We present results along the lines of the two main categories of the questions (*demographics*, *report culture*) in the order of the relevant questions. Summary perspectives from the free text analysis were provided where applicable.

RESULTS

Demographics

In total, 242 complete and eligible responses were recorded and available for evaluation. Most of the responses (78%) were collected from European specialists. The remaining responses included 11% from Asia, 5% from Africa, 5% from Americas and 1% from Oceania (Fig. 1A). Of all responders, 51 (21%) were nuclear medicine specialists, 99 (41%) were radiologists, 52 (22%) were dual-board certified and 22 (9%) were residents in either nuclear medicine or radiology. Of note, 12 (5%) responders were medical physicists, radiographers or oncologists (Fig. 1B). As far as we are aware, these responses described the reporting situation in their institution rather than doing the reporting themselves. Of all responders, one third and two thirds were female and male, respectively and most were between 35 y and 50y of age (Fig. 1C). The level of experience with PET/CT imaging as measured by years of engagement varied between 0-1 y (16%), 2-5 y (31%), 6-10 y (26%), 11-15 y (17%) or longer (12%) as indicated in Figure 1D.

In 18% sites (44/242) no joint report is generated for clinical PET/CT imaging. Of these 44 sites, 15 (6% of total responses) create separate reports for PET and CT. Likewise, 24 sites report that no joint assessment or conclusion is available, thus, accounting for 10% of all responding sites. In the case of separate reports, most are generated by nuclear medicine specialists (39%), radiologists (19%), both in consensus (21%) or dual-board certified readers (16%). In case a joint PET and CT report is created (198/242 sites), reporting is done by a nuclear medicine physician (19%), a radiologist (9%), both in consensus (52%) or a dual-board certified reader (16%). There were no differences in the demographic sub-groups nor obvious variation between geographical regions.

The average annual throughput per centre was 1490 +/- 50 PET/CT examinations. Overall, 43% sites reported an annual throughput of 1000, or less. Of all examinations, the majority of scans (59%) was performed with a low-dose CT protocol. The use of iv and oral contrast was frequent (60%-100% of examinations) in 36% and 22% of responding sites. In case of CT contrast agents being employed, 23% sites reported a change in the responsibility for reporting, presumably from a nuclear medicine physician to a radiologist when contrast was used. There were no differences in the demographic sub-groups.

Reporting teams were reported to be mixed with nuclear medicine experts (nuclear medicine physicians and/or dual-board certified physicians) being part of 96% of teams (Fig. 2A). Teams typically include a mix of nuclear medicine and radiology expertise (board certified and residents), while 9/242 sites (4%) indicate a reporting team comprised solely of a radiologist. In 1 institution a medical oncologist was included in the reporting team. Representation at tumor boards is shown in Figure 2B. Here, nuclear medicine physicians present PET/CT findings in 29% boards; this number increases to 73% if accounting for alternating and consensus presentations, or the presence of dual-board certified experts. Again, there were no differences in the demographic sub-groups.

Reporting culture

Only 55% reports were indicated to be done according to the EANM/SNMMI 2014 guideline for FDG-PET/CT imaging (*16*), whereas 30% responders indicated that they were unaware of these guidelines (Fig. 3A). Of the latter group, 11% were nuclear medicine physicians, 69% radiologists, and 14% had a dual-board certification. Report structures varied across sites with respect to the priority being accorded to one component of the investigation or the other. Most sites (38%) report the PET with supplementary localization information from CT; 27% report along the lines of a CT report with supplementary PET information (Fig. 3B). In comparison, 11% sites report the CT first and then the PET, while 26% sites indicated doing the reporting the other way around. Free-text comments were added by 16% participants. Most of them explained in detail how PET and CT data were integrated into one report (e.g., “PET and CT are woven together, and it is clearly stated when PET-findings and CT-findings are described”). Some responses (14/242) included a free text related to completely integrated reporting that differs from combined PET and CT reporting, by quoting, for example, a “symbiotic” or “synoptic integrative” report. Half the users always compare current PET/CT images to prior images, 47% do so if prior images are available (Fig. 3C).

Figure 4 summarizes a range of quantitative parameters together with their frequencies describing either the imaging procedure of findings together with an indicator (red: required, orange: recommended) in reference to (*16*). It can be seen that a significant number of reports miss out recommended information, such as patient weight and height and even the radiotracer. One third of the reports include information on the TNM stage of the oncology patient in all reports, while 34% and 12% reports include this information occasionally or for selected tumors only (Fig. 5A), such

as lung cancer, gastrointestinal cancer and head-and-neck cancer. In case of therapy response assessment, various well-established criteria are available to provide the reporting expert with relative measures indicative of the level of progression of the disease. Figure 5B indicates that these criteria are employed only in between 15% (EORTC) and 57% (Deauville) of cases. All results are available upon request from the corresponding author.

DISCUSSION

Our survey demonstrates a marked heterogeneity in clinical reporting schemes for combined PET/CT imaging. Although the vast majority of reporting teams included a nuclear medicine physician or dual-trained specialist, the actual reporting process varied greatly. Given the range of anatomical imaging protocols employed, it is not surprising that the role of the radiologist was less well defined. Our study supports two key findings relevant to the quality of PET/CT reporting. First, a significant number (18%) indicated that no joint molecular and anatomical imaging report is generated for clinical PET/CT imaging. Second, 30% of the responders were not aware that guidelines for FDG-PET/CT exist (*16*). Disconcertingly, 45% of the responders do not employ these guidelines routinely (Fig 3A).

Several non-profit organizations and professional associations have published imaging procedure guidelines and recommendations for reporting (*5,16-19*), including a list of the essential elements required within a clinical report (*7,20,21*). The reporting guidance by Niederkohr and colleagues from 2013 stated specifically that the "accuracy of image interpretation and the quality of the diagnostic report are crucial to the continued success of PET/CT in the medical community" (*7*). This statement should be seen in light of a conclusion drawn from a recent study on malpractice in radiology: "Communication failures are ubiquitous in medicine and lead to a variety of medical errors and patient harm. They are the third most common cause of malpractice against radiologists after diagnostic errors and procedural complications." (*22,23*). Thus, the quality of the combined nuclear medicine and radiology report is of utmost importance (*24*).

In general, communication among physicians is a key factor in healthcare delivery. Two key aspects of high-quality PET/CT reporting should be considered by every reader. First, the report should cover the essential elements, such as the clinical history, the imaging procedure, the description of comparison studies (if available), the delineation of findings (relevant and incidental) as well as a (final) impression (*25*). Examples for essential report elements for FDG-PET/CT imaging are provided by the SNMMI PET PROS Initiative (*17*) or in the recommendations by Niederkohr et al. (see Table 1 in (*5*)). Second, the PET/CT report should also integrate the CT data by clearly describing the CT technique, which can be categorized as "low-dose" thereby referring to a non-enhanced CT with reduced tube current settings (used for the purpose of coarse anatomical location and CT-based attenuation correction) or "high-quality"

thereby making reference to a “radiological, diagnostic equivalent” CT examination with higher tube output and the use of contrast agents (if applicable) (*16*). The PET PROS initiative (*17*) provides the essential elements of PET/CT reporting in detail. According to these guidelines, a report should be structured with description of the findings being station-based moving cranio-caudally and the report should contain a clinically relevant description of the impressions, thereby not deliberately separating the findings from CT and PET. An alternative approach is to adopt a TNM-based reporting scheme, which, in our experience, is appreciated by oncologists.

In addition to the structure of the report and the list of essential elements, the choice of reported parameters, such as standardized uptake values, uptake times etc. may also vary. Our results show a comparatively wide variation of the reported quantitative parameters (Fig. 4). The EANM/SNMMI guideline for FDG-PET/CT imaging, for example, requires readers to report a range of essential parameters (e.g., radiopharmaceutical, the amount of injected activity in MBq and/or mCi); our data show that mandatory parameters were not reported in up to 30% of cases. On the other hand, it is known that general practitioners do not value inclusion of examination technique or details of contrast media used (*26*), and it is likely that oncologists share this view with respect to technical PET/CT details within the imaging report. This might explain why some participants do not follow the guidelines (Fig. 3A).

Nonetheless, following the introduction of clinical hybrid imaging two decades ago, a minimum set of reporting standards should be accepted by now in order to support state-of-the-art patient management. By adhering to a high-quality reporting strategy, expectations of our referring clinical partners can be met more easily, most of whom prefer to receive standardized reports that consist of templates with separate headings for each organ system (*27*). Furthermore, Buckley et al. (*28*) measured the referrer’s return call rate following the receipt of unstructured and structured radiology reports. The authors demonstrated that structured radiology report format can positively impact the referring clinician’s ability to understand the critical findings. According to Brady et al., nuclear medicine physicians and radiologists (*11*) should try to put themselves into the position of the clinical end-user when reporting, thus, increasing the likelihood of the referrer to clearly understand the meaning of their report and the relevance if their interpretations.

As a consequence, we see a need to discuss harmonization and standardization of procedures including reporting. Training in nuclear medicine and radiology should provide education of reporting instructions as well. According to Bosmans et al., 92% of clinicians and 95% of radiologists comment that structured reporting should be an obligatory part of their residency training (*27*). The results of our survey attest to this intent also in the context of hybrid imaging. Nonetheless, complexity arises from the fact that hybrid imaging faces many practical and political challenges in real life, since it is driven to a large extent by both nuclear medicine and radiology specialists, who, for the most cases, are not aligned well in daily practice and who's specialty curricula are not always aligned (*14*). Until these issues are resolved, other professional recommendations by renowned experts may be useful, at least for advancing local training and reviewing local reporting practices (*25,29,30*).

In line with the conclusion from existing but sparse reporting recommendations (e.g., (*7*)) the hybrid imaging community should strive to ensure that PET/CT reports are consistently of high quality, which should entail a standardized structure and clinically-relevant language. The results of this survey may help motivate us to reflect critically on our local practice and to consider potential adaptations to the way we report our imaging results. As part of such community effort, it seems reasonable to ask for nuclear medicine and radiology associations to work more closely to clarify the existing ambiguities in professional imaging reporting.

Limitations

Our study had some limitations. First, survey response was voluntary (Appendix 1) but, therefore, likely to be biased towards involvement of motivated experts (*31*). Thus, we assume that the actual heterogeneities of PET/CT reporting regimens are far larger than reported here. Nonetheless, neither the samples nor their size of such survey responses can be planned a priori. Second, some responders did not provide eligible answers to every question asked (so-called item non-response (*32*)). This is a problem inherent to survey research itself, regardless of its format or mode of administration. Third, our responses are skewed towards a euro-centric perspective, given the majority of eligible inputs received from there. Finally, our survey did not address in detail all aspects of hybrid imaging reporting. We composed a series of questions that—based on our experience—mirror the variability of reporting. If adherence to

guidelines was to be tested in clinical reality, a regional or global survey performed by societal organizations across the globe would be required.

CONCLUSION

A 2018 survey of mainly European PET/CT users demonstrated a marked variation in PET/CT reporting cultures and the overall lack of a cross-center standard for PET/CT reporting. Most notably, 18% responders report that they do not follow a joint PET and CT reporting scheme despite the full integration of PET and CT within PET/CT instrumentation. Results from this limited survey call for a follow-up by professional organizations in an effort to promote high-quality standards in PET/CT reporting.

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DUALITY-OF-INTERESTS

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Rodney Hicks has received travel support from Siemens Healthineers and GE Medical Systems.

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FIGURES

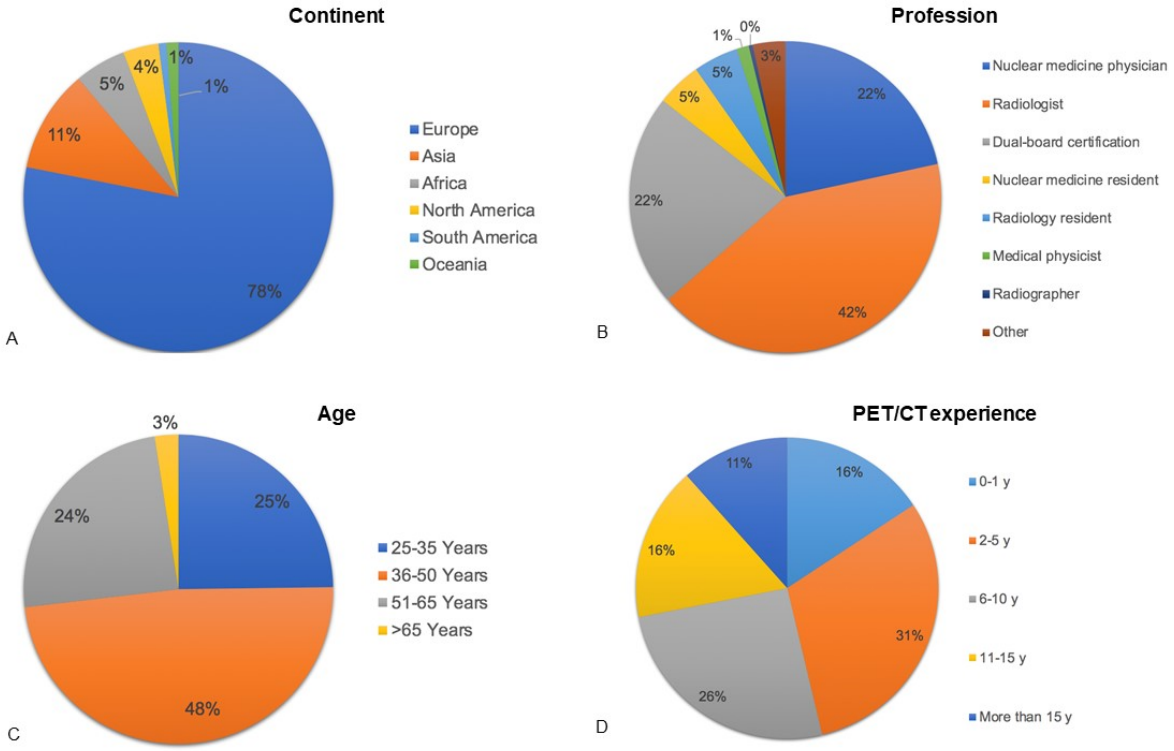

Figure 1. Demographic responses (242 eligible responses): (A) continent of origin of the responder, (B) professional background, (C) age, and (D) years of experience with clinical PET/CT.

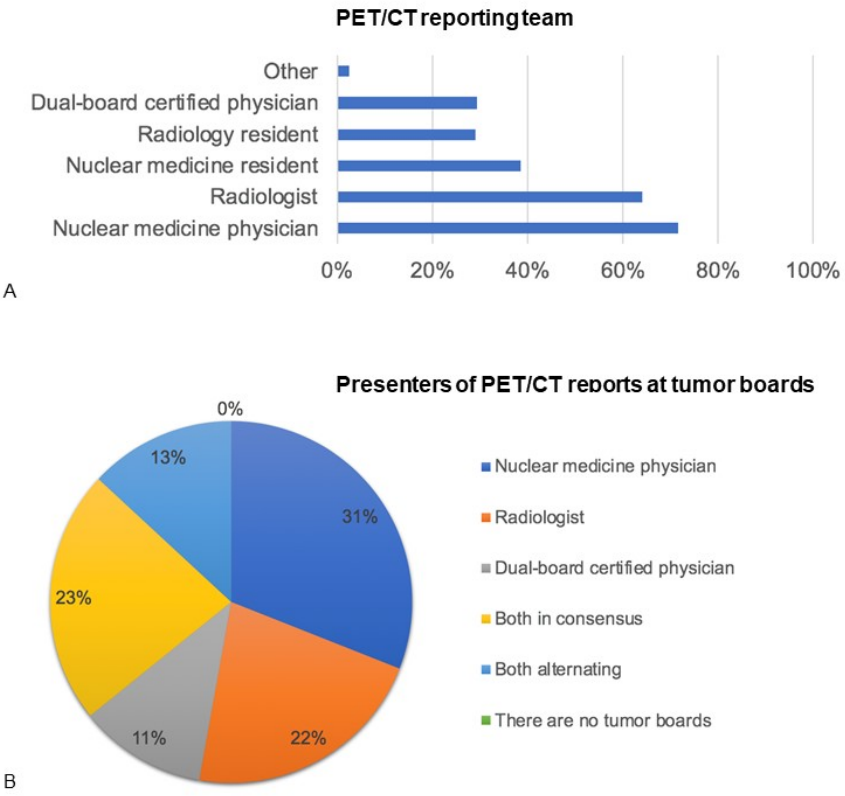

Figure 2. (A) Composition of the reporting teams for PET/CT studies in % of all responses. (B) Tumor board representation in % of all responses.

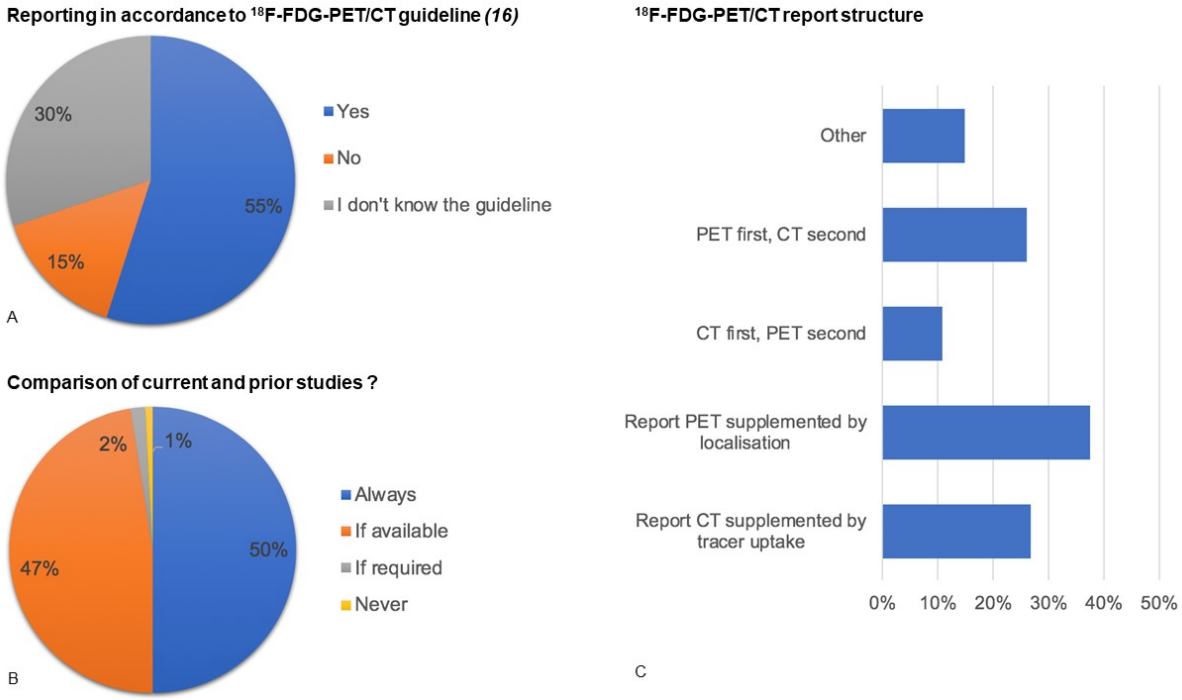

Figure 3. (A) Concordance (% sites) of PET/CT reporting with EANM/SNMMI guidelines (*16*). (B) Frequency (% sites) of structured PET/CT reporting. (C) Frequency (% site) of including prior imaging examinations in reading and reporting of current PET/CT studies.

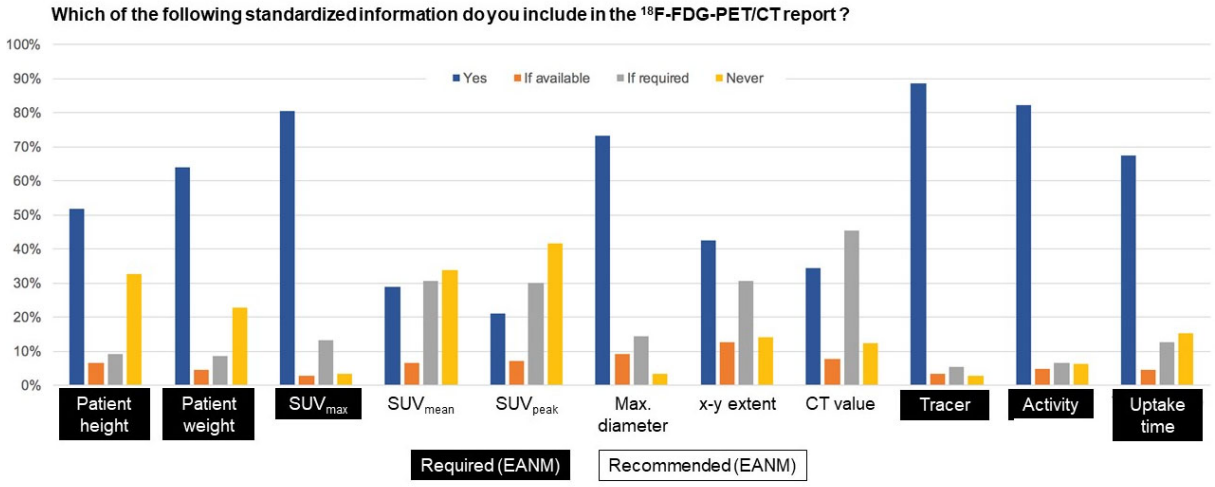

Figure 4. Inclusion frequency of key parameters in PET/CT reports with reference to EANM/SNMMI guidelines for FDG-PET/CT (*16*): black box = required and white box = recommended. The response "if required" means "if mandated by the referring physician. Of note, other parameters are discussed in the guideline (*16*) that were not surveyed in this study.

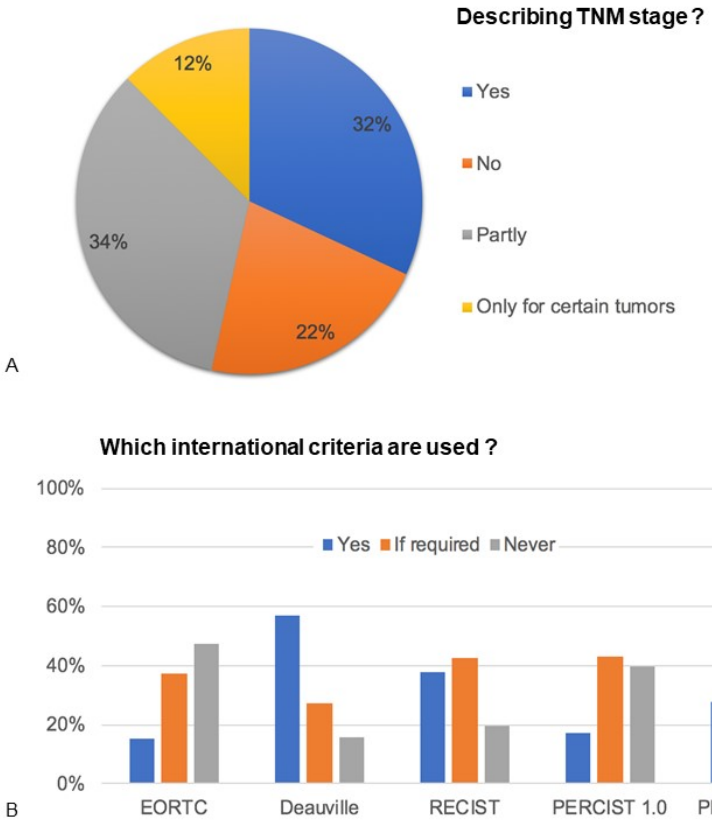

Figure 5. (A) Number (%) responders who report the TNM stage. (B) Frequency (%) of including international criteria in PET/CT reports. The response “if required” means “if mandated by the referring physician.

APPENDIX 1

Complete list of questions from the survey on PET/CT reporting as defined in GoogleDocs: http://eshi-society.org/12bqydxn01ky8a/ (*password* : ESHIsurvey123).

1. Do you create a joint report for PET/CT examinations?
2. Who writes the report?
3. Do you create separate reports for PET and CT?
4. Is there a joint assessment or conclusion?
5. Who writes the report?
6. How many PET/CT examinations does your institution perform per year?
7. How many % of your PET/CT examinations are performed with a low-dose / full-dose CT?
8. What factors determine your decision?
9. How many % of your PET/CT examinations are performed with intravenuous contrast agents?
10. How many % of your PET/CT examinations are performed with oral contrast agents?
11. Does the responsibility for reporting change when contrast agents are used?
12. If yes, how?
13. Who provides the justified indication for .... at your institution?
    a. PET
    b. CT
    c. PET/CT
14. Who is part of the reporting team?
15. Who presents PET/CT reports at tumor-boards?
16. Do you report in accordance with the EANM guideline (FDG-PET/CT)?
17. Are the individual body regions reported separately (ENT/thorax/abdomen/pelvis/skeleton)?
18. How is the report structured?
19. Do you compare current images with prior studies?
20. Which of the following standardised information do you include?
    a. Patient height [cm]

b. Patient weight [kg]

c. SUV max

d. SUV mean

e. SUV peak

f. Max. diameter [mm]

g. x-y extent [mm]

h. CT value [HU]

i. Tracer

j. Amount of radioactivity [MBq]

k. Time of uptake [min]

21. Which of the following international criteria do you use?

    a. EORTC

    b. Deauville

    c. RECIST

    d. PERCIST 1.0

    e. PERCIST 2.0

22. Do you describe the TNM stage?

23. If "only for certain tumors", for which ones?

24. My gender

25. My place of work is in

26. My age

27. My profession

28. My experience with PET/CT