[18]F-fluoride PET/CT: Experience and image quality assessment in patients with prostate cancer and suspected bone metastases

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Abstract

The aim of this study was to investigate patients' previous knowledge, satisfaction and experience regarding a ^{18}F-fluoride positron emission tomography/computed tomography examination (^{18}F-fluoride PET/CT) and to explore whether experienced discomfort during the examination or pain was associated with reduced image quality. A further aim was to explore if patients' health-related quality of life (HRQoL) was associated with their satisfaction and experiences of the examination. **Methods:** Fifty consecutive patients with a histopathological diagnosis of prostate cancer who were scheduled for ^{18}F-fluoride PET/CT were asked to participate in the study, between November 2011 and April 2013. A questionnaire was used to collect information regarding the patients' previous knowledge and experience of the examination. Image quality assessment was performed according to an arbitrary scale. The EORTC-QLQ-C30 and QLQ-PR25 were used to assess HRQoL. **Results:** Forty-six patients (96%) completed the questionnaires. Twenty-six per cent of participants did not know at all what a ^{18}F-fluoride PET/CT examination was. The majority (52-70%) were to a very high degree satisfied with the care provided by the nursing staff but less satisfied with the information given prior to the examination. The image quality was similar in patients who were exhausted or claustrophobic during the examination and those who were not. No correlations between HRQoL and the participants' experience of ^{18}F-fluoride PET/CT were found. **Conclusions:** The majority of participants were satisfied with the care provided by the nursing staff, but there is still room for improvement especially regarding the information prior to the examination. Long examination time may be strenuous, for the patient but there was no difference in image quality between patients who felt discomfort during the examination or pain and those who did not.

Key Words: Fluoride PET/CT, prostate cancer, patient satisfaction, experience, image quality

Introduction

Imaging with positron emission tomography (PET) combined with computed tomography (CT) demands well-trained nursing staff and well prepared patients who adhere to the nursing staff's instructions in order to secure a successful examination including high image quality. However, a recent survey regarding patients' understanding of radiologic imaging revealed that the level of understanding was the lowest among patients who were scheduled for nuclear medicine examinations (*1*).

Patients undergoing examinations at a nuclear medicine department may experience anxiety and fear for example fear of injections or fear of being trapped in the scanner (*2*). Information regarding the examination procedure and interaction with the nursing staff may be ways to reduce such fears and improve patient's ability to cooperate during the examination and thereby reduce motion artefacts and improve image quality(*2-5*). Acuff and colleges found that improved communication between patients and the staff may reduce patients' anxiety during a PET/CT examination but concluded that further research is needed to investigate whether reduce anxiety has an impact on image quality (*6*).

PET/CT with the bone-seeking tracer ^{18}F-fluoride provides both morphological and anatomical information and has in the last few years been increasingly applied for the diagnosis of bone metastases especially in prostate cancer patients (*7*). ^{18}F-fluoride is an old tracer that has found new clinical use because of the increasing number of PET/CT scanners and the consequently better availability of the technique. ^{18}F-fluoride PET/CT has shown better sensitivity and specificity than traditional bone scintigraphy (*8*).

Prostate cancer patients with metastatic disease may suffer from symptoms and a decreased physical functioning (*9,10*). This increases the risk for significant discomfort during the PET/CT examination. In our study on patients' experiences of ^{18}F-fluorodeoxyglucose PET/CT several correlations between patients' experiences and health-related quality of life (HRQoL) were found, such as those between high satisfaction and a better physical functioning. High discomfort was shown to be correlated with more pain, fatigue, and dyspnea (*11*). However, the impact of discomfort on the image quality was not evaluated.

Patients' satisfaction and experiences in connection with imaging procedures consequently need to be considered, and improvements to reduce the patients' discomfort are of high importance. There are still no studies regarding patients' experiences of a ^{18}F-fluoride PET/CT examination and the association with image quality. A poor patient experience may result in poor image quality, delayed diagnostics and treatment and may thereby, in the wider perspective result, in low confidence in the healthcare system.

Aims

The primary aim of this study was to investigate patients' previous knowledge, satisfaction and experience regarding a ^{18}F-fluoride PET/CT examination and to explore whether experience of discomfort during the examination or pain affected the image quality negatively. A secondary aim was to explore if patients' HRQoL was associated with their satisfaction and experiences of the examination.

MATERIALS AND METHODS

Patients

Fifty consecutive patients with a histopathological diagnosis of prostate cancer and apparent or suspected bone metastases who were scheduled for ^{18}F-fluoride PET/CT were asked to participate in the study from November 2011 to April 2013. The exclusion criterion was inability to communicate in Swedish. The study was approved by the regional ethics review board in Uppsala, Sweden (No.2011/277). All participants signed a written informed consent.

PET/CT scanner

The ^{18}F-fluoride PET/CT examination was performed on a Discovery ST PET/CT Scanner (GE Healthcare; (12)) one hour after an IV injection of 3Mbq/kg bodyweight of ^{18}F-fluoride.The PET component of this scanner has a field of view of 15.7 cm in axial and 70 cm in transaxial direction. The scanner consists of 24 detector rings, resulting in 47 image planes with a slice thickness of 3.27 mm. Following a low-dose CT scan for attenuation correction, a whole-body scan is acquired by moving the patient through the field of view of the scanner in steps, acquiring one axial field of view at a time. The scan was acquired from the middle of the patient's thigh to the top of the skull. The acquisition time was two minutes/bed position in 3D mode, totaling approximately 20 minutes.

Procedure

After completion of the ^{18}F-fluoride PET/CT examination the patients were asked to participate in the study. They received oral and written information from the nursing staff who carried out the examination or from the first author (CA). Patients who agreed to participate received a questionnaire either to complete while still at the department or to bring home and return within one month by post, in a stamped self-addressed envelope. A reminder and a copy of the questionnaire were sent by post to participants who had failed to reply after three weeks.

Data collection

Data on age, gender, marital status, level of education, and monthly income were collected with study specific questions.

Patient previous knowledge, satisfaction and experience

Study specific questions were used to investigate participants previous knowledge of the ^{18}F-fluoride PET/CT examination (0 = "not at all" to 3 = "quite a lot"), the satisfaction with the information about the examination procedure and the interaction with the nursing staff (0 = "not at all" to 4 = "to a very high degree"), and discomfort, that is how exhausting the examination was (0 = "not at all exhausting" to 3 = "very much exhausting"), to what extent the examination corresponded to the participants expectations (0 = "much easier" to 4 = "much worse"); and to what extent the participant felt trapped (claustrophobia) during the examination (0 = "not at all trapped" to 3 = "very much trapped). Five questions from the Patient Experiences Questionnaire (PEQ) (*13*) was used to investigate the interaction with the nursing staff, the communication, their professional skills and the overall impression of the hospital (0 = "not at all" to 4 = "to a very high degree"). The questionnaire also provided opportunities for the patient to supply free-text comments.

Health-related quality of life

The European Organization for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaire (QLQ-C30) and the prostate cancer specific module (QLQ-PR25) was used to assess HRQoL. The QLQ-C30 is transformed to five functional scales, nine symptom scales and a global quality-of-life (QoL) scale and the QLQ-PR25 to one function scale and five symptom

scales. All scales are linearly transformed into a 0-100 scale, with higher scores reflecting more symptoms, higher levels of functioning, and better global health status/quality of life (*14,15*).

Image quality assessment

The image quality assessment was performed by a senior radiologist, who used a project-specific form with an arbitrary 3-point scale to rate image artefacts, lesion conspicuity, extent of image impairment, overall diagnostic accuracy, and number of pathological findings (suspected bone metastases).

Data analysis

Data were analyzed by using Statistical Package for Social Sciences, SPSS version 20.0. Descriptive statistics were used for analyses of the demographic data and the patients' responses to questions regarding their previous knowledge, satisfaction and experience of the ^{18}F-fluoride PET/CT examination. Participants' free-text comments were analyzed using categorization of responses. Mann-Whitney U test was used to analyze differences between patients who had undergone the examination previously and those who underwent the examination for the first time. Spearman's correlation coefficient was used to investigate how patient previous knowledge, satisfaction and experience of the examination were correlated to HRQoL and how previous knowledge was correlated to satisfaction and experience of the examination. Correlations to HRQoL were restricted to scales/items that were most likely to be influenced by the experience of the examination that is the functional scales, dyspnoea, fatigue, and pain. The level for statistical significance was set at $p < 0.01$ (two-tailed), due to the large amount of correlation analysis. The relation between image quality and the patient's previous knowledge regarding the examination, and exhausting and claustrophobic experience or pain were analyzed descriptively.

RESULTS

Participants

Forty-eight of 50 patients accepted to participate in the study and 46 of 48 (96%) completed the questionnaire. The majority (n = 40) completed the questionnaire at home. All participants were outpatients. The mean age of the participants was 69 years (range 59-83; Table 1). Ten participants was previously diagnosed with bone metastasis, 9 had suspected bone metastases on other imaging examinations (CT or magnetic resonance imaging), and 27 were without bone metastasis, according to the referral form. Six participants had previously undergone ^{18}F-fluoride PET/CT, and 19 participants had undergone PET/CT with another tracer such as ^{18}F-fluorodeoxyglucose PET/CT or ^{11}C-acetate PET/CT.

Patient previous knowledge, experience, and satisfaction

None of the participants knew "very much" about the ^{18}F-fluoride PET/CT prior to the examination, and only two knew "very much" about how the examination was conducted (Table 2). The majority was satisfied with the information regarding the examination to a "high" or a "very high degree" (Table 3). However, 20% (n = 9 of 46) were satisfied with the information they received prior to the examination only to "some degree". The majorities of the participants, 65-70% (n = 30-32) were satisfied with the interaction with the nursing staff, their communication abilities, and their professional skills to a "very high degree".

Patient discomfort

The majority of the participants did not experience claustrophobia during the examination, however, 27% or (n = 12 of 45) felt "some" claustrophobia (Table 2). Most of the participants did

not think that the examination was exhausting at all, but 27% (n = 12 of 45) thought that the examination was "some" or "much" exhausting. Eleven participants gave comments on what they regarded as exhausting during the examination. Nine of them commented on physical factors such as the arms position during the time spent in the PET/CT camera (n = 5), or uncomfortable camera bed (n = 4). The remaining two participants commented on emotional factors such as distress and claustrophobia. Forty-four of 45 stated that the examination was as expected or easier to undergo than expected (Table 2).

Imaging quality assessment

There were no differences in image quality with regard to previous knowledge about the examination, experienced discomfort, or pain. There were small artefacts in one patient's images. All other images were without artefacts. Lesion conspicuity was excellent, all anatomical regions were fully diagnostic and the overall diagnostic accuracy was determined as fully diagnostic in all images. Nineteen patients had no bone metastases according to the ^{18}F-fluoride PET/CT, 21 had occasional bone metastases (1-5), and six patients had many bone metastases ($\geq$6; Table 4).

Health-related quality of life

Global health status was relatively high (mean 74; Table 5). Mean functional scale scores ranged between 87 and 92. Role functioning was the best (mean 92), and emotional functioning the worst (mean 87) among the functional scales. Nausea and vomiting were the mildest symptoms (mean 1) and insomnia the worst (mean 21). There were no statistically significant correlations between HRQoL and the participants' experiences or satisfaction of the ^{18}F-fluoride PET/CT.

DISCUSSION

This is the first study investigating prostate cancer patients' experiences of a ^{18}F-fluoride PET/CT examination, image quality and factors associated with that. Aspects of information regarding ^{18}F-fluoride PET/CT yielded the lowest proportion of highly satisfied patients. Twenty-six percent of the participants did not know at all what a ^{18}F-fluoride PET/CT examination was. Most of the participants felt no discomfort during the ^{18}F-fluoride PET/CT procedure similar to what has previously been reported regarding patients' experiences of undergoing ^{18}F-fluorodeoxyglucose PET/CT (*11*). The image quality assessment revealed an overall high image quality and participants' previous knowledge, discomfort during the examination, and pain did not affect the image quality negatively.

The present result suggesting that discomfort did not affect the image quality indicates that patients are able to adhere to the nursing staff's instructions, even during an uncomfortable examination. Studies regarding magnetic resonance imaging suggest that there is a need for information interventions to reduce motion artefacts due to discomfort and thereby improve image quality (*3,5*). Thus, our findings may indicate that ^{18}F-fluoride PET/CT may be less sensitive to motion artefacts compared to magnetic resonance imaging. However, the present study was performed in a fairly small group of patients of whom only a few felt discomfort during the examination. Also, these patients merely had occasional metastatic lesions, and the result may be different in those with more disseminated bone metastases. Thus, further investigations in larger groups of patients including those with more advanced disease are warranted.

Keeping the arms positioned over the head was regarded as the most strenuous part during the PET/CT examination. Apart from using physical devices to support the arms during examination, and a call device to reduce anxiety during examination (*6*), the nursing staff may also help the

patient to develop different coping strategies to endure an uncomfortable examination situation, by, for example, environmental distractions such as music (*2*). There was no difference regarding discomfort during examination between participants who had previously undergone a PET/CT examination and those who had not.

The HRQoL was relatively high, global health status was 74, which is similar to findings of two other studies regarding prostate cancer patients HRQoL (*10,16*). There were no correlations between the HRQoL and the patients' experiences or satisfaction of the examination. One possible explanation for these results could be that the participants merely had occasional bone metastases.

The present study has several limitations. The questionnaire used to collect data included some questions constructed by the authors that had not been evaluated with regard to validity and reliability. However, these questions had been used in a previous study regarding patients' experience of an ^{18}F-fluorodeoxyglucose PET/CT examination. The high response rate and the low number of unanswered questions indicate that the patients found the questionnaire relevant and easy to understand. The validity of the study results may be limited by the small number of patients. However, this is one of the first investigations on patients' experiences of PET/CT examination and thereby contributes relevant findings in a previously virtually unexplored area of research. Also some patients were informed and asked to participate in the study by the nursing staff who had executed the examination. This may imply a risk for false positive answers from patients who did not want to hurt the nursing staff. Some questions received responses from less than 92% of the participants. Questions regarding the use of incontinence aids and those pertaining to sexual function had the lowest response rates, probably because they were considered too personally intrusive and the patients therefore were reluctant to reply to these

types of questions. This is, however, not considered to have had a major impact on the outcome of this study.

CONCLUSION

The majority of participants were satisfied with the care provided by the nursing staff, but there is still room for improvement especially regarding the information prior to the examination. The time spent in the PET/CT scanner, especially with the arms positioned over the head, may be strenuous for the patients but there were no differences in image quality between patients who felt discomfort during the examination and those who did not. The occurrence of bone metastases appeared not to affect the image quality negatively. Future studies are suggested to investigate patient experiences of ^{18}F-fluoride PET/CT and factors associated with the image quality in larger populations and also including those with more advanced disease.

DISCLOSURE

The authors declare no conflict of interest.

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Table 1
The demographic characteristics for the
study population (n = 46)

	Mean	Range
Age	69	59-83
	N	**%**
Civil status		
Married/cohabitant	37	80
Single	7	15
Widow/widower	2	4
Education		
Compulsory school	16	36
Upper secondary school	13	29
University 0-4 years	5	11
University > 4 years	11	24
Occupation		
Working	15	33
Sick leave	1	2
Studies	0	0
Homework	0	0
Unemployed	0	0
Other	29	64
Monthly income (SEK)		
0-4999	1	2
5000-9999	0	0
10000-14999	6	14
15000-19999	8	19
20000-24999	8	19
25000-29999	7	17
30000-34999	5	12
> 35000	7	17

Table 2
Prostate cancer patients previous knowledge and discomfort regarding an ^{18}F-fluoride PET/CT examination (n = 46)

	n (%)
Did you know before the examination what a PET-fluoride examination was?	
Not at all	12 (26)
Some	16 (35)
Quite a lot	18 (39)
I knew very much	0
Did you know before the procedure how the PET-fluoride examination was conducted?	
Not at all	11 (24)
Some	18 (39)
Quite a lot	15 (33)
I knew very much	2 (4)
Did you feel trapped during the examination?	
Not at all	33 (73)
Some	12 (27)
Much	0
Very much	0
How exhausting was the examination?	
Not at all	33 (73)
Some	9 (20)
Much	3 (7)
Very much	0
Was the examination as you had expected it to be?	
Much easier	10 (22)
A bit easier	10 (22)
Just as I expected	24 (53)
A bit worse	1 (2)
Much worse	0

Table 3

Patients satisfaction at ^{18}F-fluoride PET/CT examination as measured by questions from PEQ and those designed for this study (n = 46)

	Not at all	To a low degree	To some degree	To a high degree	To a very high degree
	n (%)	n (%)	n (%)	n (%)	n (%)
Are you satisfied with the information you received prior to the examination?	0	1 (2)	9 (20)	18 (39)	18 (39)
Are you satisfied with the information you received when you came to the examination?	0	0	3 (7)	19 (41)	24 (52)
Are you satisfied with the interaction with the nursing staff during the examination?	0	0	1 (2)	13 (28)	32 (70)
Did the nursing staff communicate in an understandable way?	0	0	0	16 (35)	30 (65)
Did the nursing staff convey a caring attitude?	0	0	0	15 (33)	31 (67)
Did you feel confident in the professional skills of the nursing staff?	0	0	0	15 (33)	31 (67)
Did the nursing staff have adequate time for you when you needed them?	0	0	0	17 (37)	29 (63)
Did you get the impression that the work of the hospital was well organized?	0	0	5 (11)	20 (46)	19 (43)

Table 4

[18]F-fluoride PET/CT image in relation to previous knowledge regarding the examination and discomfort or pain during the procedure (yes/no)

	Claustrophobia		Exhausting		Pain		Knowledge	
	Yes	No	Yes	No	Yes	No	Yes	No
	n=12	n=33	n=12	n=33	n=17	n=29	n=34	n=12
Artefacts								
No	12	32	11	33	16	29	33	12
Minor	0	1	1	0	1	0	1	0
Major	0	0	0	0	0	0	0	0
Lesion conspicuity								
Execellent	12	33	12	33	17	29	34	12
Intermediate	0	0	0	0	0	0	0	0
Poor	0	0	0	0	0	0	0	0
Extent of image impairment								
All anatomical regions fully diagnostic	12	33	12	33	17	29	34	12
Occasional regions impaired	0	0	0	0	0	0	0	0
Several regions impaired	0	0	0	0	0	0	0	0
Overall diagnostic accuracy								
Fully diagnostic	12	33	12	33	17	29	34	12
Minor impairment	0	0	0	0	0	0	0	0
Major impairment	0	0	0	0	0	0	0	0
Image findings								
No metastases	4	15	4	15	6	13	13	6
Occasional (1-5)	7	14	6	15	8	13	15	6
Many (≥6)	1	4	2	3	3	3	6	0

Discomfort (claustrophobia/exhausting), No = not at all, Yes = some to much. Pain, No = not at all, Yes = any level of pain. Knowledge, No = not at all, Yes = some to very much

Table 5
Health-related quality of life of prostate cancer patients
scheduled for an 18F-fluoride PET/CT examination measured by
the EORTC-QLQ-C30 and EORTC-QLQ-PR25

EORTC-QLQ-C30		N	Mean	SD
Global health status	QoL	45	74	22
Functional scales				
Physical functioning	PF	45	91	15
Role functioning	RF	45	92	18
Emotional functioning	EF	46	87	17
Cognitive functioning	CF	46	90	15
Social functioning	SF	46	90	16
Symptom scales/items				
Fatigue	FA	45	16	18
Nausea and vomiting	NV	45	1	6
Pain	PA	46	13	20
Dyspnoea	DY	45	13	19
Insomnia	SL	45	21	28
Appetite loss	AP	45	2	8
Constipation	CO	45	7	18
Diarrhea	DI	46	7	17
Financial difficulties	FI	46	8	26
EORTC-QLQ-PR25				
Urinary symptoms	PRURI	45	20	15
Incontinence aid	PRAID	8	8	15
Bowel symptoms	PBOW	43	5	7
Treatment related symptoms	PRHTR	46	16	16
Sexual activity	PRSAC	46	24	27
Sexual functioning	PRSFU	17	56	31