Scientific Research Publishing

Open Journal of Biophysics, 2024, 14, 79-98
https://www.scirp.org/journal/ojbiphy
ISSN Online: 2164-5396
ISSN Print: 2164-5388

Contribution of Bone Scintigraphy in the Metastatic Extension Assessment of Prostate Cancer: A Study of 288 Cases in the Nuclear Medicine Department of Idrissa Pouye General Hospital, Dakar

El Hadji Amadou Lamine Bathily[1,2], Ousseynou Diop[2,3], Mamoudou Salif Djigo[1,2], Gora Thiaw[1], Kalidou Gueye[1], Mohamed Chekhma[1], Olatounde Herbert Fachinan[1], Boucar Ndong[2,3], Omar Ndoye[2], Mamadou Mbodj[1,2]

[1]Department of Nuclear Medicine, Idrissa Pouye General Hospital (HOGIP), Dakar, Senegal
[2]Biophysical Laboratory, FMPO, Cheikh Anta Diop University (UCAD), Dakar, Senegal
[3]Department of Nuclear Medicine, Hospital Dalal Jamm, Dakar, Senegal
Email: *bathilyssd@yahoo.fr

How to cite this paper: Bathily, E.H.A.L., Diop, O., Djigo, M.S., Thiaw, G., Gueye, K., Chekhma, M., Fachinan, O.H., Ndong, B., Ndoye, O. and Mbodj, M. (2024) Contribution of Bone Scintigraphy in the Metastatic Extension Assessment of Prostate Cancer: A Study of 288 Cases in the Nuclear Medicine Department of Idrissa Pouye General Hospital, Dakar. *Open Journal of Biophysics*, **14**, 79-98.
https://doi.org/10.4236/ojbiphy.2024.142005

Received: January 14, 2024
Accepted: February 4, 2024
Published: February 7, 2024

Abstract

Introduction: Prostate cancer is the most frequently diagnosed male malignancy and the fifth leading cause of cancer death in men worldwide. Since the advent of screening methods such as Prostate Specific Antigen (PSA) assay, digital rectal examination (DRE) and prostate biopsy, its incidence has increased significantly. The aim of our study was to analyse aspects of bone scintigraphy (BS) as part of the metastatic extension assessment of prostate cancer in Senegal. **Patients and Methods**: This was a retrospective descriptive and analytical study, running from January 1er 2022 to August 31 2023. Patients with histologically confirmed prostate cancer were included. Whole-body scans (WBS) were performed using a dual-head SPECT gamma camera (Mediso Nucline TM Spirit DH-V type), 3 hours after intravenous injection of 8 MBq/kg (555 to 740 MBq) of ^{99m}Tc-HMDP. **Results**: A total of 288 patients with a mean age of 68.37 ± 7.79 years were included. The median total PSA level was 97.6 ng/ml, with 144 patients having a level greater than or equal to 20 ng/ml. All patients had adenocarcinoma, and the Gleason score was available in 202 (70.13%) patients, 75.75% of whom had a score greater than or equal to 7. BS was contributory in 70.48% of cases, with 30.90% positive and 39.58% negative. The result was inconclusive in 85 patients (29.51%). The mean PSA for patients with a positive scan was 190.2 ng/ml and 40.6 ng/ml for those with a negative scan. Multiple metastatic lesions predomi-

nated (87.35% of cases). Metastatic lesions occurred preferentially in the axial skeleton, with a proportion of 68% versus 32% in the appendicular skeleton. Classification of bone metastases according to the SOLOWAY score revealed grade I (62.07%), grade II (35.63%) and grade IV (2.30%). **Conclusion**: In Senegal, prostate cancer is generally diagnosed in men of advanced age. The presence of bone metastases is frequent in its evolution, transforming a curable localized disease into a generalized disease with a compromised prognosis. Bone scintigraphy remains an essential part of the initial work-up and evaluation of response to treatment.

Keywords

Prostate Cancer, Bone Metastasis, Bone Scintigraphy, Senegal

1. Introduction

Prostate cancer is the most frequently diagnosed male malignancy and the fifth leading cause of cancer death in men worldwide. This represented 1,414,249 newly diagnosed cases and 375,000 deaths worldwide per year from the disease in 2020 [1]. Since the advent of screening methods such as Prostate Specific Antigen (PSA), the digital rectal examination (DRE) and prostate biopsy, its incidence has risen sharply. Incidence is higher among African Americans and lower among Asians, with white Caucasians from USA having an intermediate incidence [2]. In Africa, the estimated incidence rate of prostate cancer was 22/100,000 in 2016. The International Agency for Research on Cancer (IARC) has cited prostate cancer as a growing health threat in Africa, with an estimated 28,006 deaths in 2010 and 57,048 deaths in 2030. The exact incidence of advanced and metastatic prostate cancer in sub-Saharan Africa is not known [3]. In sub-Saharan Africa, prostate cancer was the leading cancer among men in terms of incidence (77,300 cases), followed by liver cancer (24,700 cases) and colorectal cancer (23,400 cases). Prostate cancer was the leading incident cancer among men in 40 sub-Saharan African countries [4]. Older age, height, ethnic origin and family history of prostate cancer are the only proven risk factors [5]. In our regions, this cancer is often diagnosed late, at an advanced or metastatic stage. This delay in diagnosis is linked, among other things, to the absence of systematic screening and difficulties in accessing healthcare [6]. Several imaging tests can be performed to diagnose bone metastases. These include radiography, computed tomography (CT), bone scintigraphy, magnetic resonance imaging (MRI), Positron Emission Tomography (PET). Bone scintigraphy (BS) with metastable technetium-labelled bisphosphate (^{99m}Tc) remains indicated in the guidelines for the detection of bone metastases prior to treatment of intermediate-risk and high-risk prostate cancer (PCa). It also retains a place in assessing response to treatment for secondary bone disease [7] [8].

The aim of our study was to analyse the aspects of scintigraphy in the context

of the bone extension assessment of prostate cancer in Senegal.

2. Patients and Methods

2.1. Type of Study

This was a retrospective descriptive and analytical study, from January 1, 2022 to August 31, 2023, of prostate cancer patients who had undergone bone scintigraphy with ^{99m}Tc-HMDP. It took place in the nuclear medicine department of Idrissa Pouye General Hospital (HOGIP) in Dakar. Operational since June 2009, it remains the only functional nuclear medicine department in Senegal. The nuclear medicine department at the Idrissa Pouye General Hospital was chosen as the setting for the study, since it is the only nuclear medicine department currently in operation in the whole of Senegal.

Whole-body scintigraphy (WBS) bone scans were performed using a dual-head SPECT gamma camera (Mediso Nucline TM Spirit DH-V type), 3 hours after intravenous injection of 8 MBq/kg (555 to 740 MBq) of ^{99m}Tc-HMDP.

2.2. Study Population

For the selection of patients, we opted for the most exhaustive sampling, taking into account all patients with prostate cancer who benefited from bone scintigraphy.

➢ Inclusion criteria

All patients with histologically confirmed prostate cancer and who underwent whole-body bone scintigraphy were included in the study. In addition, the Gleason score given by the pathologist and the PSA assay should be available at the same time, or one of them.

➢ Non-inclusion criteria

Not included in our study:

- Patients who did not have both a Gleason score and/or a PSA assay, and those with incomplete medical records (socio-demographic and clinical data not provided),
- Patients who have undergone bone scintigraphy for reasons other than prostate cancer extension.

2.3. Studied Variables

➢ Dependent variable

The dependent variable of the study was the presence or absence of bone metastasis. It presented three modalities: yes for presence of metastasis, no for absence of metastasis, and doubtful (doubtful presence of metastasis).

➢ Independent variables

- General data: age, weight, family history of cancer, duration of evolution,
- PSA levels,
- Histological and prognostic data: histological type, Gleason score,
- Scintigraphic data:

*Indication for scintigraphy: initial extension workup, monitoring, biochemical recurrence, follow-up workup;

*The dose of ^{99m}Tc-HMDP administered;

*Contributory or non-contributory scintigraphy;

*Presence or absence of bone metastases;

*Single or multiple metastasis location(s);

*Topographies of metastatic bone lesions;

*Type of bone lesions (hyper-fixing, hypo-fixing, mixed);

*Quantification of bone damage using the SOLOWAY score.

2.4. Data Collection

- To collect and process the data, we used:

*Patient bone scan records from the software database (InterViewXP/Médiso);

*Scintigraphy prescription forms and physical records (observation sheets) for each patient included;

- Bone scan images during the study period were all visualized and analysed;
- For each file, the data were transcribed onto a data processing form designed for the study. This form was tested and corrected on some twenty files.

2.5. Data Processing and Analysis

Data were recorded and analysed using Excel and Epi Info (French version). Quantitative variables are expressed as averages, while qualitative variables are expressed as percentages.

Quantitative variables were compared using the Fisher test. A value of $p < 0.05$ was considered significant.

2.6. Ethical Considerations

All ethical requirements relating to health research were respected. Patient data were treated confidentially and in strict compliance with medical secrecy. Data sheets were completed anonymously, using an identification code. Confidentiality of the data collected was ensured.

3. Results

3.1. Age

A total of 288 patients were enrolled, with a mean age of 68.37 years and a standard deviation of 7.79 years. The median age was 69 years, with extremes ranging from 43 to 88 years. The age range]60 - 80] was the most frequent, accounting for 78.47% of patients (**Figure 1**).

3.2. Family History of Cancer

In our study, 67 patients (23.26%) had a family history of cancer. Of these, 36 patients (53.73%) were first degree related, 19 patients (8.36%) were second

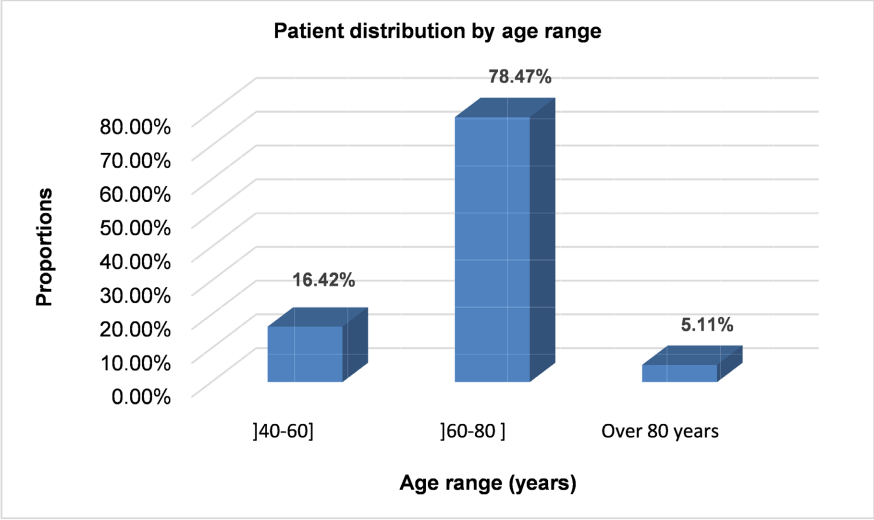

Figure 1. Patient distribution by age range.

degree related and 12 patients (7.91%) were third degree related (**Figure 2**).

3.3. PSA Levels

In our study, PSA levels were available in 221 patients, *i.e.* 76.73% of cases. Of these, 144 patients (65.61%) had a PSA level above 20 ng/ml and 39 patients (17.65%) had a PSA level between 10.1 and 19.9 ng/ml.

The figure below (**Figure 3**) shows the distribution by PSA level.

3.4. Development Time

The duration of evolution of clinical signs in relation to histological confirmation was analysed in 248 patients, *i.e.* 86.11% of cases. The mean evolutionary time was 3.3 years, with extremes ranging from 1 month to 20 years. The most common duration was over 36 months, with a percentage of 29.44, followed by between 6 and 12 months.

The figure below (**Figure 4**) shows the distribution of evolution times.

3.5. Histological and Biochemical Aspects

3.5.1. Histological Type

The histological type of prostate cancer in our patients was adenocarcinoma in the entire study population.

3.5.2. Gleason Score

In our series, the Gleason score was available for 202 patients (70.13%).

The proportion of patients with a Gleason score less than or equal to 6 was 24.26%, or 49 patients. Those with a Gleason score equal to 7 accounted for 43.07% (87 cases). Patients with a Gleason score greater than or equal to 8 represented 32.68%, or 66 patients.

Of the patients for whom Gleason scores were available, 192 (95.04%) had detailed scores. The score 7 was represented by the value 3 + 4 in 21.35% and the

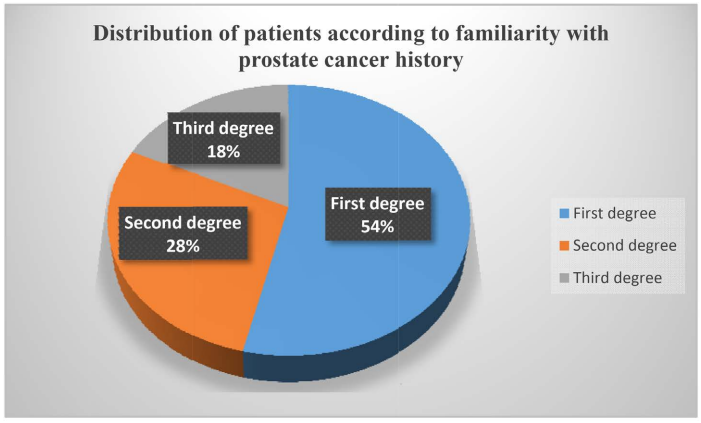

Figure 2. Distribution of patients according to familiarity with prostate cancer history.

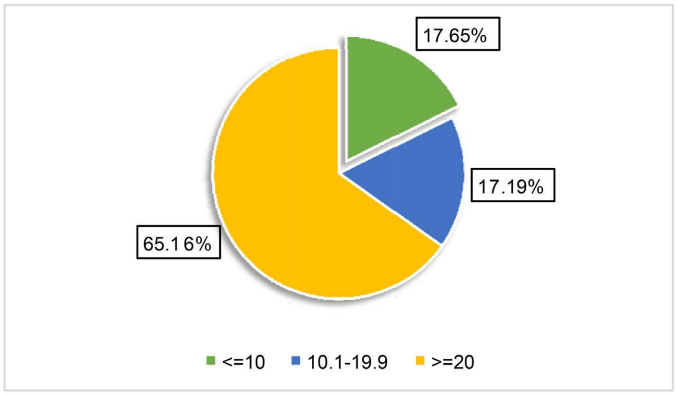

Figure 3. Distribution by PSA level.

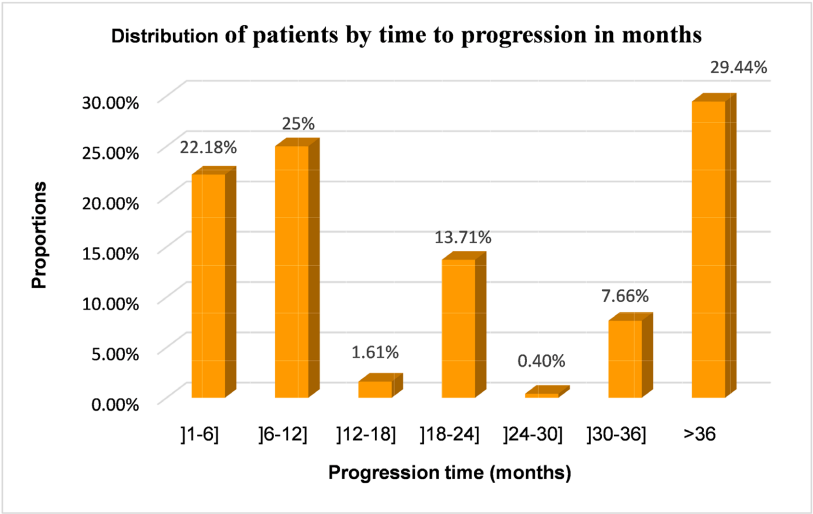

Figure 4. Distribution of patients by time to progression in months.

value 4 + 3 in 21.88%.

The figure below (Figure 5) shows the distribution of patients according to Gleason score, and details of the score are given in Table 1.

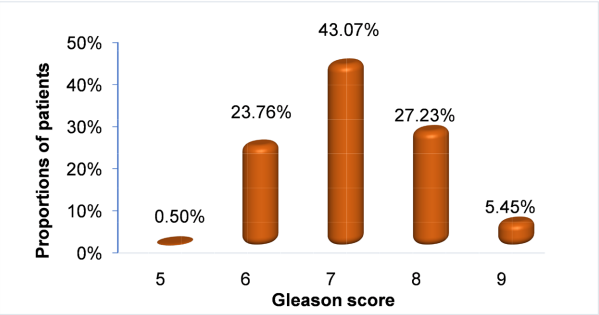

Figure 5. Distribution of patients by Gleason score.

Table 1. Distribution of patients by Gleason score details.

Score details	Frequencies	Proportions
2 + 3	1	0.52%
3 + 3	46	23.96%
3 + 4	41	21.35%
3 + 5	2	1.04%
4 + 3	42	21.88%
4 + 4	50	26.04%
4 + 5	6	3.13%
5 + 4	4	2.08%
Total	192	100.00%

3.6. Radiopharmaceutical Activity and Patient Weight

The following table (Table 2) shows the relationship between the mCi activity of the radiopharmaceutical (^{99m}Tc-HMDP) and patient weight.

In our study, the mean dose of radiotracer activity administered for the standard weight range [70 - 90 kg[was 16.9 mCi, with extremes of 12.03 mCi and 20 mCi. Table 2 shows the distribution of injected activity by weight range.

3.7. Scintigraphy Data

3.7.1. Indication for Scintigraphy

In our series, almost all patients (96.43%) underwent initial extension workup.

The figure below (Figure 6) shows the distribution of patients according to the indications for scintigraphy.

3.7.2. Contribution of Scintigraphy

Scintigraphy was contributed in 70.48% of cases, with 30.90% showing the presence of metastases and 39.58% the absence of metastases. The result was doubtful in 85 patients, *i.e.* 29.51% of cases. The figure below (Figure 7) shows the distribution of patients according to the presence or absence of bone metastases.

3.7.3. Solitary or Multiple Bone Metastases

In our series, metastases were solitary in 12.64% of cases and multiple in 87.35%.

Table 2. Patient weight andradiotracer (^{99m}Tc-HMDP) doses.

Weight (kg)	Average dose (mCi)	Minimum (mCi)	Maximum (mCi)
Under 50 Kg	14.84	8.38	18
[50 - 70 Kg[	16.17	10	18.9
[70 - 90 Kg]	16.9	12.03	20
Over 90 Kg	17.54	13.4	21.63

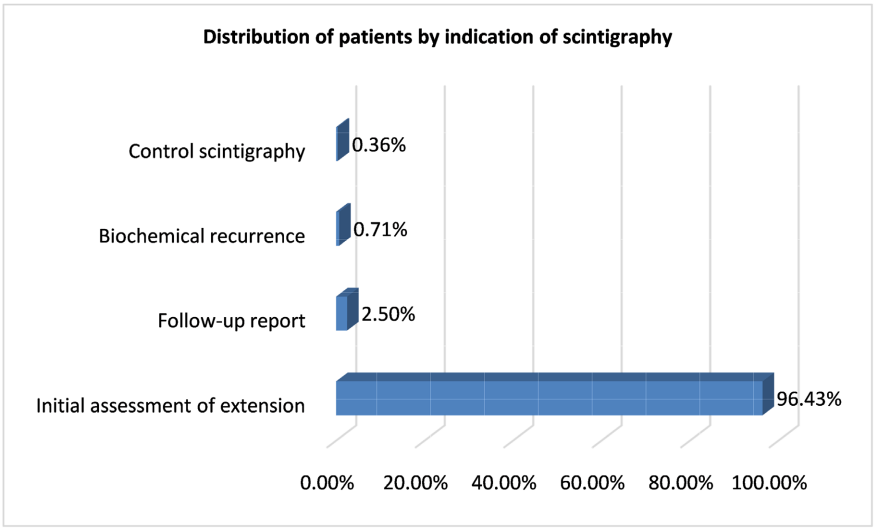

Figure 6. Distribution of patients by indication of scintigraphy.

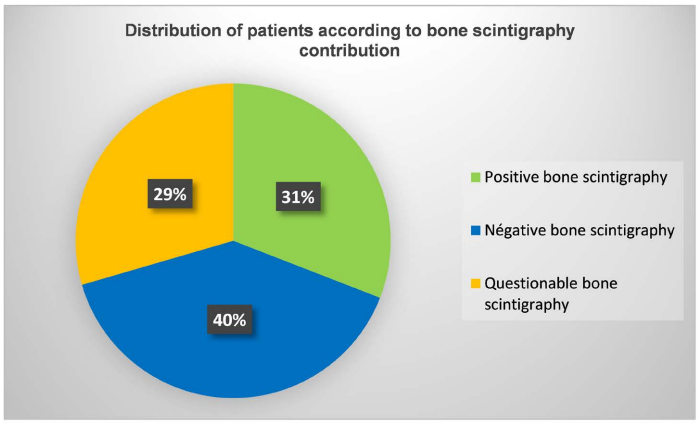

Figure 7. Distribution of patients according to bone scintigraphy contribution.

Table 3 shows the breakdown by number of metastases.

3.7.4. Bone Lesions Topography

❖ Lesions site

Our study showed that of the 425 metastatic lesions, 68% (290 lesions) were located on the axial skeleton, against 32% (135 lesions) on the appendicular skeleton (**Figure 8**).

Table 3. Distribution of patients by single or multiple metastases.

Locations	Frequencies	Proportions
Multiple	76	87.35%
Single	11	12.64%
Total	87	100.00%

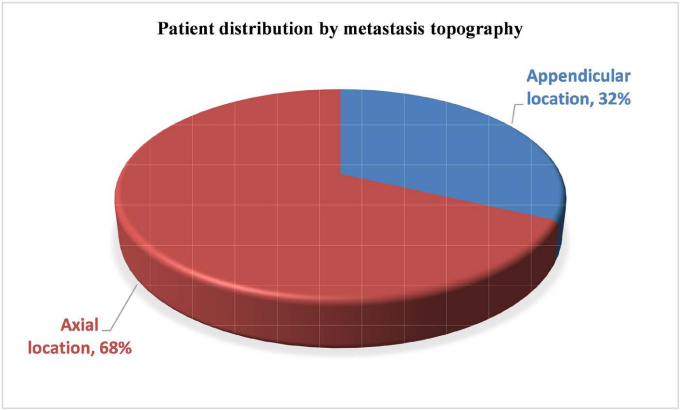

Figure 8. Patient distribution by metastasis topography.

❖ Precise skeletal Topography

For patients with bone metastases, our study showed that 53 lesions were found at rib level (12.47%), 45 lesions at sacroiliac level (16.22%), 45 lesions at skull level (10.58%), 41 lesions at dorsal spine level (9.64%) and at lumbar spine level. **Table 4** shows the various axial skeletal locations.

3.7.5. Hyper-Fixing or Hypo-Fixing Nature of Bone Metastases

In our series, all metastatic bone lesions were of the hyper-fixating, osteoblastic type.

3.8. PSA Levels and Presence or Absence of Metastases

PSA is an important biomarker for diagnosis and active surveillance, although it is not a specific marker for prostate cancer.

In our study, the mean PSA level was 97.6 ng/ml, with extreme values ranging from 0.006 ng/ml to 791.6 ng/ml, and a median of 31.17 ng/ml:

- Those with metastases on scintigraphy had a mean PSA level of 190.2 ng/ml, a median of 138.6 ng/ml and extremes of 0.006 to 791.6 ng/ml;
- Patients without metastases had a mean PSA level of 40.6 ng/ml, a median of 49.2 ng/ml and extremes of 0.006 to 243 ng/ml;
- For those with a doubtful scan, their mean PSA level was 81.5 ng/ml, with a median level of 29.6 ng/ml and extremes from 0.02 to 702 ng/ml (**Table 5**).

3.9. Quantification of Bone Damage

The SOLOWAY score was used to quantify metastatic bone lesions. Fifty-four (54) patients were grade I, including 11 solitary lesions. Thirty-three (33) patients,

Table 4. Distribution of bone metastases in the axial skeleton.

Locations	Frequencies	Proportions
Ribs	53	12.47%
Sacroiliac	45	10.58%
Skull	45	10.58%
Iiliac wings	44	10.35%
Dorsal spine	41	9.64%
Lumbar spine	41	9.64%
Pubis	36	8.47%
Sternum	32	7.52%
Sacrum	24	5.64%
Clavicle	12	2.82%
Femur	11	2.58%
Cervical spine	09	2.11%
Shoulder blade	09	2.11%
Humerus	09	2.11%
Pelvic girdle	09	2.11%
Shoulder	04	0.94%
Tibia	01	0.23%
Total	425	100%

Table 5. Distribution of PSA levels according to scintigraphy results.

Scintigraphy results	Average (ng/ml)	Standard deviation	Mediane	Minimum (ng/ml)	Maximum (ng/ml)
Presence of metastases (Yes)	190.2	204.1	138.6	0.006	791.6
No metastases (No)	40.6	49.2	19.2	0.006	243.0
Doubtful or Litigious	81.5	125.7	29.6	0.02	702.0

or 37.93%, had a SOLOWAY score greater than or equal to II.

Table 6 shows the distribution of patients with bone metastases according to the SOLOWAY scintigraphy score.

4. Discussion

4.1. Age

The mean age of our patients was 68.37 years, with extremes ranging from 43 to 88 years. The [60 - 80] age group was the most affected, with 78.47% of patients. This result is comparable to that reported by B. Ndong *et al.* [9], who in a study

Table 6. Distribution of patients with bone metastases according to Soloway classification.

SOLOWAY Score	Frequencies	Proportions
A single bone lesion (Grade I)	11	12.64%
Grade I : Less than 6 metastases	43	49.43%
Grade II: Between 6 et 20 metastases	31	35.63%
Grade IV: Super bone scan	2	2.30%
Total	87	100.00%

of 45 patients found an average age of 66.71 years (extremes: 50; 80 years). Other studies carried out in Senegal had similar results, which corroborate our data [6] [10]. A study by Ndoye M *et al*. and Zaman M. U. *et al*. reported an average age of 71 years [11] [12]. Other studies from Asia [13] [14] and Europe [15] had also reported an increase in average age compared with our study. It is uncommon before the age of 50, but becomes more common between the ages of 60 and 70, particularly in developing countries. This trend can be explained by the lack of awareness of the disease and the absence of adequate screening programs. In addition, limited access to specialized care services poses a further challenge.

4.2. Family History of Cancer

The presence of a family history of prostate cancer is an important factor to consider when assessing an individual's risk of developing the disease. In our study, we found that 23.26% of patients had a family history of prostate cancer. This suggests a genetic predisposition to the disease, and raises questions about the influence of hereditary susceptibility in the development of prostate cancer. Among patients with a family history, we observed different kinship relationships with family members with prostate cancer. Of the 67 patients concerned, 53.73% were 1st degree relatives, meaning that they were brothers or fathers of patients with the disease. This genetic proximity reinforces the hypothesis of hereditary transmission of prostate cancer susceptibility. What's more, 28.36% of patients were 2nd degree relatives, including uncles, nephews or grandfathers with the disease. These less direct kinship relationships, but still sharing a certain proportion of the genetic heritage, also suggest a genetic contribution to the incidence of prostate cancer. Finally, 17.91% of patients had 3rd degree relationships, encompassing cousins, great-grandfathers or first cousins with the disease. Although the genetic influence may be less marked in these cases, the presence of prostate cancer in these branches of the family still indicates a familial predisposition.

These findings underscore the importance of family history in assessing individual prostate cancer risk. Systematic collection of a family history of cancer, particularly prostate cancer, can help identify high-risk patients who may benefit from early detection and close surveillance. Furthermore, these data support the

idea of a genetic component in prostate cancer susceptibility and encourage future research into the identification of specific genetic markers associated with this disease. It should be noted that our study has certain limitations, including a relatively small sample size and a specific population. Larger and more diversified studies are needed to confirm our observations and better understand the role of genetic factors in the development of prostate cancer [2] [16]-[22].

4.3. Time to Market

In our series, the time from cancer diagnosis to bone scan varied considerably, from one month to twenty years. A significant proportion of patients (29.44%) had a time to progression of more than 36 months. Earlier studies, such as that by Diop *et al*. [23], had also found delays ranging from six months to seven years.

The precise dates of onset of metastases and their duration of evolution are not known for our patients, as was mentioned in the research by Diop *et al*. [23].

In our context, scintigraphic examinations are not performed on a regular basis due to the regular unavailability of radiopharmaceuticals and sometimes technical problems. Patients therefore do not benefit from regular follow-up scintigraphy, which could enable early detection of metastases, an essential element in optimal cancer management.

In summary, there are wide variations in the time between cancer diagnosis and bone scan, ranging from a few months to several years. Constraints related to the availability of scintigraphic examinations in our country, due to radiopharmaceutical and technical problems, result in irregular follow-up with scintigraphy, compromising early detection of metastases and adequate management of the cancerous disease.

4.4. Histological Appearance

In our series, the exclusive histological appearance observed was that of adenocarcinoma, in line with the findings reported by B. Ndong *et al*. [9]. However, other studies by L. Niang *et al*. [6] and M. Ndoye *et al*. [11] reported a case of sarcoma in their respective series. These observations indicate that sarcomas are rare, representing less than 1% of prostate tumours. Moreover, they tend to occur in subjects under 50 years of age.

4.5. Gleason Score

In 70.13% of patients in our series, the Gleason score was obtained from prostate biopsies following an increase in PSA and/or an abnormal digital rectal examination. The Gleason score is a histopronostic indicator used to differentiate tumours according to their tumour architecture and to classify them according to grades of increasing malignancy.

In our study, 23.76% of patients (*i.e*. 46 patients) had a Gleason score of 6 (3 + 3), 43.07% of patients had a Gleason score of 7 (3 + 4 or 4 + 3), 27.23% of pa-

tients had a Gleason score of 8 (4 + 4), and 5.45% had a Gleason score of 9 (4 + 5 or 5 + 4). The Gleason score was subdivided into three groups: the group with a Gleason score less than or equal to 6, representing 24.26% of patients; the group with a Gleason score equal to 7, representing 43.07% of patients; and finally the group with a Gleason score greater than or equal to 8, representing 32.68% of patients.

According to the 2013 onco-urology guidelines [24], high-risk prostate cancer is defined by a Gleason score greater than or equal to 8, or equal to 7 but with a predominance of grade 4 or 5, or by the presence of cancer on more than 50% of biopsies, or by positive biopsy lengths greater than 20%. Thus, in our study, 32.68% of patients (Gleason score ≥ 8) belonged to this high-risk cancer group. It should be noted that patients with a Gleason score equal to 7 (4 + 3) were also included in this high-risk cancer group due to the predominance of grade 4. Furthermore, several studies have shown that in 25% of cases, a Gleason score equal to 7 underestimated the true Gleason score of prostate cancer [25].

This makes it difficult to classify cancers with a Gleason score equal to 7 between the intermediate-risk and high-risk groups. The low-risk group was represented in our series by 24.26% of patients (Gleason score ≤ 6). However, to define this group, all the parameters of D'Amico's classification are required [24].

These results reveal a discordance with clinical stage and PSA levels, underlining a diagnostic delay in the detection of the disease in our countries. Anatomopathological analysis, on the other hand, reveals a large number of low-risk cancers. This may be explained by the lack of pathologists in our countries, such as Senegal, and by the fact that the pathologists available are not specialized in uropathology. In addition, access to immunohistochemical studies is limited.

4.6. Radiopharmaceutical Activity and Patient Weight

In our study, there was no correlation between the activity of the radiopharmaceutical administered and patient weight, with a correlation coefficient r = 0.31. In principle, the activity to be administered to patients should be a function of their weight, *i.e.* 8 MBq of radiobiphosphonate per kg of patient weight, without exceeding 1000 MBq. Staff must be made more aware of the need to correlate radiopharmaceutical doses with weight. However, these doses were always in line with the standards of the French Society of Nuclear Medicine, the European Society of Nuclear Medicine and the American Society of Nuclear Medicine, which recommend 15 to 20 mCi for patients of standard weight (60 - 80 kg).

4.7. Indication for Scintigraphy

The majority of indications for bone scintigraphy in patients were related to the initial extension workup, accounting for 96.43% of cases. A limited number of cases (2.5%) were related to follow-up workup, while only 0.71% of cases were related to biochemical recurrence. A study by Punnen and colleagues [26] high-

lighted the importance of medical imaging in the management of cancer pathologies, noting almost 30% of biochemical recurrence in their sample. However, it should be noted that nuclear imaging in the management of cancer pathologies is not limited solely to extension assessment. The results obtained suggest that the lack of adequate nuclear imaging equipment in Senegal may explain these findings. Many authors have argued in favor of the use of 18F-FCholine PET/CT for the detection and localization of recurrences in patients with biochemical relapse [27] [28] [29] [30] [31].

Other studies have demonstrated the importance of identifying recurrence sites by 68Ga-PSMA-11 PET/CT imaging, in order to propose loco-regional or systemic treatment. These studies have also revealed a higher positivity rate for 68Ga-PSMA-11 PET/CT imaging than for 18F-FCholine PET/CT [32]-[37].

It is important to note that these results underline the need for an adequate nuclear imaging technical platform for better management of prostate cancer patients in Senegal. Advances in imaging techniques, such as the use of 68Ga-PSMA-11 PET/CT, may enable more accurate detection of recurrences and thus propose more targeted treatments. However, efforts must be made to improve access to these advanced imaging technologies in countries where they are not yet available.

4.8. Contribution of Scintigraphy

Scintigraphy was contributed in 70.48% of cases (203 cases) in our study. In 29.51% (85 cases), the result was doubtful. Of the patients who underwent scintigraphy, 30.90% had a positive scan, while 39.58% had a negative scan. These results are consistent with those of the study by Ndong and colleagues, who also observed a similar positive scan rate of 33.33% in their study [9]. With the improvement of nuclear imaging equipment in Senegal, notably SPECT/CT and PET/CT, doubtful cases could be explored more precisely. The advantage of this is more appropriate patient management. Thanks to these technological advances, it becomes possible to refine diagnostic results and better assess the extent of the disease, which can lead to more informed therapeutic decisions and improved clinical outcomes. It is important to emphasize that improving the technical platform for nuclear imaging must be supported by ongoing investment in infrastructure and training of medical staff. This will optimize the use of these advanced imaging modalities and guarantee quality care for prostate cancer patients in Senegal.

4.9. Topography of Lesions

In our sample, multiple metastatic lesions predominated, accounting for 87.35% of metastases. This observation is in line with the results of other studies, which also found a high prevalence of multiple metastatic lesions [9] [23] [38]. In our study, metastatic lesions were mainly located in the axial skeleton. These results are consistent with those reported in the literature [9] [23] [38]. Indeed, tumour

cells tend to localize preferentially, though not exclusively, in the most richly vascularized regions of the skeleton, such as the hematopoietic bone marrow of the axial skeleton, and the upper extremities of the humerus, femur and tibia [39] [40].

Furthermore, our study revealed that, in descending order, 52.43% of metastatic lesions were at the spinal level, 46.53% of metastatic lesions at the pelvic girdle level, 15.63% of metastatic lesions at the skull level, 12.50% at the thoracic girdle level, and 9.03% of metastatic lesions on the appendicular skeleton. These results are virtually identical to those reported by some authors in the literature [9] [23] [41]. These observations highlight the tendency of metastases to localize preferentially in specific skeletal regions such as the axial skeleton, which may have important implications for treatment planning and follow-up of patients with bone metastases.

4.10. Types of Bone Lesions

The results of our study showed a predominance, if not exclusivity, of hyperfixating bone lesions among metastases. This observation has also been highlighted by some authors in the literature [23] [38]. It is important to note that bone hyperfixation is suggestive of metastases, but is not specific, which can make differential diagnosis difficult [42]. Indeed, there may be confusion between metastases and benign pathologies that result in significant bone remodelling, particularly when osteoblastic hyperfixation foci are unique and/or located in particular anatomical regions (e.g. close to joints) [42]. This non-specificity of bone hyperfixation underlines the importance of a comprehensive diagnostic approach and the use of other imaging modalities to confirm or exclude the diagnosis of bone metastases. Additional investigations, such as biopsies or advanced imaging, may be required to establish an accurate diagnosis and differentiate metastatic lesions from benign pathologies. It is essential to take these considerations into account when interpreting imaging results and to consult other clinical data in order to arrive at an accurate diagnosis and propose appropriate management to patients a tainted with bone metastases.

4.11. PSA Levels and Positive Scintigraphy

Of the 288 patients with prostate cancer, those with metastases on scintigraphy had a mean PSA blood level of 190.2827 ng/ml and a median of 138.6 ng/ml with extremes of 0.006 to 791.6 ng/ml. Patients without metastases had a mean PSA blood level of 40.6 ng/ml and a median of 19.2 ng/ml, with extremes ranging from 0.006 to 243 ng/ml.

Already described in the literature, PSA blood levels correlate with the presence of metastases [9]. Jemal and colleagues showed that a PSA level above 10 ng/ml was indicative of localized prostate cancer; a level above 50 ng/ml was indicative of extra-prostatic involvement in 80% of cases; and a level above 100 ng/ml was indicative of systematic involvement.

4.12. Quantification of Bone Damage

The SOLOWAY score was used in our study to assess the quantity of metastatic bone lesions.

This quantification method revealed that around forty percent of patients with metastases (37.93%) had a poor prognosis, with a grade equal to or greater than II. This indicated that these patients either consulted late or had poor outpatient follow-up, as previously mentioned. This finding is also confirmed in the literature [9] [43]. For prostate cancer patients, mean and median PSA levels increased significantly with SOLOWAY score grades. This increasing relationship between SOLOWAY grades and PSA levels has already been described in the literature [44] [45]. These results underline the importance of the SOLOWAY score in assessing the prognosis and follow-up of patients with bone metastases in prostate cancer.

Using this quantification method, it is possible to identify high-risk patients and implement closer monitoring, which can have an impact on therapeutic decisions and improved clinical outcomes.

The results of our study lead us to formulate recommendations for the development of nuclear medicine in Senegal.

The results of this study highlight several important elements related to the diagnosis of prostate cancer, underlining the importance of an advanced diagnostic and therapeutic approach using nuclear medicine. In Senegal, it would be beneficial to consider capacity building in the field of nuclear medicine to better manage prostate cancer patients. As a first step, investment in nuclear medicine equipment, such as SPECT-CT and PET/CT, would be essential to enable accurate and reliable molecular imaging examinations. These tools would more effectively enable early cancer diagnosis, initial staging and treatment evaluation. Targeting the PSMA with PET tracers labelled with ^{18}F or ^{68}Ga would mark an important turning point in the early management and follow-up of cancerous disease.

The acquisition of SPECT-CT will reduce the number of lesions classified as doubtful by increasing the specificity of the examination. In fact, planar bone scintigraphy does not allow localization in 3D space, reducing the specificity of the examination. The arrival of ^{99m}Tc-PSMA will enable SPECT-CT to detect both bone and visceral lesions during the scintigraphic examination.

Finally, efforts should be made to raise awareness among the general public and healthcare professionals of the benefits of nuclear medicine in the management of prostate cancer. This would contribute to greater acceptance and adherence to these advanced techniques, as well as to earlier detection and more effective treatment of the disease.

5. Conclusions

Prostate cancer (PCa) is a common disease worldwide, ranked as the second most common cancer in men after Broncho-pulmonary cancers. Bone metasta-

ses are a frequent feature of prostate cancer, transforming a curable localized disease into a generalized disease with a compromised prognosis. Bisphosphate bone scintigraphy (BSS) with ^{99m}Tc remains a key tool in the assessment of bone extension and response to treatment of secondary bone disease.

With improved nuclear imaging facilities in Senegal (SPECT/CT and PET/CT), doubtful cases in our sample could be better explored, with the advantage of appropriate patient management. PSMA-targeted PET/CT could be a definite advantage, with better targeting of cancer cells and detection of both bone and visceral lesions.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Leslie, S.W., Soon-Sutton, T.L., Sajjad, H. and Siref, L.E. (2023) Prostate Cancer. StatPearls Publishing, Treasure Island. http://www.ncbi.nlm.nih.gov/books/nbk470550/

[2] Amin Al Olama, A., Dadaev, T., Hazelett, D.J., Li, Q., Leongamornlert, D., Saunders, E.J., *et al*. (2015) Multiple Novel Prostate Cancer Susceptibility Signals Identified by Fine-Mapping of Known Risk Loci among Europeans. *Human Molecular Genetics*, **24**, 5589-5602. https://doi.org/10.1093/hmg/ddv203

[3] Cassell, A., Yunusa, B., Jalloh, M., Ndoye, M., Mbodji, M.M., Diallo, A., *et al*. (2019) Management of Advanced and Metastatic Prostate Cancer: A Need for a Sub-Saharan Guideline. *Journal of Oncology*, **2019**, Article ID: 1785428. https://doi.org/10.1155/2019/1785428

[4] Szot, W., Kostkiewicz, M., Zajac, J., Owoc, A. and Bojar, I. (2014) Prostate Cancer in Patients from Rural and Suburban Areas—PSA Value, Gleason Score and Presence of Metastases in Bone Scan. *Annals of Agricultural and Environmental Medicine*, **21**, 888-892. https://doi.org/10.5604/12321966.1129953

[5] Cancer de la Prostate et Facteurs de Risque Cancer Environnement. Cancer Environnement. https://www.cancer-environnement.fr/fiches/cancers/cancer-de-la-prostate/

[6] Niang, L., Ndoye, M., Ouattara, A., Jalloh, M., Labou, M., Thiam, I., *et al*. (2013) Cancer de la Prostate: Quelle Prise en Charge au Senegal? *Progres en Urologie*, **23**, 36-41. https://doi.org/10.1016/j.purol.2012.09.002

[7] Cancer CCS/S Canadienne Du. Metastases Osseuses. Societe Canadienne du Cancer. https://cancer.ca/fr/cancer-information/cancer-types/metastatic/bone-metastases

[8] Couturier, O.-F., Querellou, S., Reichart, J., Pennec, R.L. and Robin, P. (2023) Scintigraphie Osseuse Monophotonique: Quelle Place Dans la Prise en Charge du Cancer de la Prostate? *Médecine Nucléaire*, **47**, 276-280. https://doi.org/10.1016/j.mednuc.2023.07.007

[9] Ndong, B., Mbodj, M., Mbaye, G., Ndoye, O., Bathily, E.H., Diouf, L., *et al*. (2012) Place de la Scintigraphie Osseuse Dans le Bilan D'extension des Metastases des Cancers de la Prostate au Senegal: Etude Preliminaire a Propos de 45 Cas. *Medecine Nucleaire*, **36**, 586-590. https://doi.org/10.1016/j.mednuc.2012.05.012

[10] Gueye, S., Jalloh, M., Labou, I., Niang, L., Kane, R. and Ndoye, M. (2004) Profil Clinique du Cancer de la Prostate au Senegal. *African Journal of Urology*, **10**, 203-207.

[11] Ndoye, M., Niang, L., Gandaho, K.I., Jalloh, M., Labou, I. and Gueye, S. (2014) Cancer Avance de la Prostate au Senegal. Aspects Diagnostiques a L'hôpital de Grand Yoff, *Progrès en Urologie*, **24**, 271-275. https://doi.org/10.1016/j.purol.2013.08.317

[12] Zaman, M.U., Fatima, N. and Sajjad, Z. (2011) Metastasis on Bone Scan with Low Prostate Specific Antigen (≤ 20 ng/ml) and Gleason's Score (< 8) in Newly Diagnosed Pakistani Males with Prostate Cancer: Should We Follow Western Guidelines. *Asian Pacific Journal of Cancer Prevention*, **12**, 1529-1532.

[13] Lee, S.H., Chung, M.S., Park, K.K., Yom, C.D., Lee, D.H. and Chung, B.H. (2012) Is It Suitable to Eliminate Bone Scan for Prostate Cancer Patients with PSA ≤ 20 ng/ml? *World Journal of Urology*, **30**, 265-269. https://doi.org/10.1007/s00345-011-0728-6

[14] Sanjaya, I., Mochtar, C.A. and Umbas, R. (2013) Correlation between Low Gleason Score and Prostate Specific Antigen Levels with Incidence of Bone Metastases in Prostate Cancer Patients: When to Omit Bone Scans? *Asian Pacific Journal of Cancer Prevention*, **14**, 4973-4976. https://doi.org/10.7314/APJCP.2013.14.9.4973

[15] Mongiat-Artus, P., Peyromaure, M., *et al.* (2009) Recommandations pour la prise en charge du cancer de la prostate chez l'homme âgé: Un travail du comité de cancérologie de l'Association Française d'Urologie. *Progrès en Urologie*, **19**, 810-817. https://doi.org/10.1016/j.purol.2009.02.008

[16] Bratt, O., Drevin, L., Akre, O., Garmo, H. and Stattin, P. (2016) Family History and Probability of Prostate Cancer, Differentiated by Risk Category: A Nationwide Population-Based Study. *Journal of the National Cancer Institute*, **108**, Djw110. https://doi.org/10.1093/jnci/djw110

[17] Eeles, R., Olama, A., Benlloch, S., Saunders, E., Leongamornlert, D., Tymrakiewicz, M., *et al.* (2013) Identification of 23 New Prostate Cancer Susceptibility Loci Using the ICOGS Custom Genotyping Array. *Nature Genetics*, **45**, 385-391. https://doi.org/10.1038/ng.2560

[18] Hemminki, K. (2012) Familial Risk and Familial Survival in Prostate Cancer. *World Journal of Urology*, **30**, 143-148. https://doi.org/10.1007/s00345-011-0801-1

[19] Lichtenstein, P., Holm, N.V., Verkasalo, P.K., Iliadou, A., Kaprio, J., Koskenvuo, M., *et al.* (2000) Environmental and Heritable Factors in the Causation of Cancer—Analyses of Cohorts of Twins from Sweden, Denmark, and Finland. *New England Journal of Medicine*, **343**, 78-85. https://doi.org/10.1056/NEJM200007133430201

[20] Ucci, L.A., Hjelmborg, J.B., Harris, J.R., Czene, K., Havelick, D.J., Scheike, T., *et al.* (2016) Familial Risk and Heritability of Cancer among Twins in Nordic Countries. *JAMA*, **315**, 68-76. https://doi.org/10.1001/jama.2015.17703

[21] Schumacher, F.R., Al Olama, A.A., Berndt, S.I., Benlloch, S., Ahmed, M., Saunders, E.J., *et al.* (2018) Association Analyses of More than 140,000 Men Identify 63 New Prostate Cancer Susceptibility Loci. *Nature Genetics*, **50**, 928-936. https://doi.org/10.1038/s41588-018-0142-8

[22] Zeegers, M., Nekeman, D., Khan, H., Van Dijk, B., Goldbohm, R., Schalken, J., *et al.* (2013) Prostate Cancer Susceptibility Genes on 8p21-23 in a Dutch Population. *Prostate Cancer and Prostatic Diseases*, **16**, 248-253. https://doi.org/10.1038/pcan.2013.9

[23] Diop, O., Bathily, E., Diouf, L.D., Djiboune, A., Kabre, S., Leye, M., *et al.* (2014)

Place de la Scintigraphie Osseuse Dans le Bilan D'extension des Metastases Osseuses du Cancer du Sein au Senegal: Etude Preliminaire a Propos de 40 Cas. *Sciences de la Sante*, **2**, 57-62.

[24] Salomon, L., Bastide, C., Beuzeboc, P., Cormier, L., Fromont, G., Hennequin, C., *et al*. (2013) Recommandations en Onco-Urologie 2013 du CCAFU: Cancer de la Prostate. *Progres en Urologie*, **23**, S69-S101. https://doi.org/10.1016/S1166-7087(13)70048-4

[25] Davin, J., Delmas, V., Lebret, T., Molinie, V., Neuzillet, Y. and Richaud, P. (2006) Cancer de la Prostate a Haut Risque. *Progres en Urologie* (*Paris*), **16**, 661-670.

[26] Punnen, S., Cooperberg, M.R., D'Amico, A.V., Karakiewicz, P.I., Moul, J.W., Scher, H.I., *et al*. (2013) Management of Biochemical Recurrence after Primary Treatment of Prostate Cancer: A Systematic Review of the Literature. *European Urology*, **64**, 905-915. https://doi.org/10.1016/j.eururo.2013.05.025

[27] Boissier, R. (2011) L'antigene Specifique de la Prostate ou PSA. *Progrès en Urologie*, **21**, 798-800. https://doi.org/10.1016/j.purol.2011.09.004

[28] Heinisch, M., Dirisamer, A., Loidl, W., Stoiber, F., Gruy, B., Haim, S., *et al*. (2006) Positron Emission Tomography/Computed Tomography with F-18-Fluorocholine for Restaging of Prostate Cancer Patients: Meaningful at PSA < 5 ng/ml? *Molecular Imaging and Biology*, **8**, 43-48. https://doi.org/10.1007/s11307-005-0023-2

[29] Huchet, V., Kerrou, K., Balogova, S., Nataf, V., Montravers, F. and Talbot, J.-N. (2008) Tomographie par EMission de Positons et Cancer de la Prostate. *Médecine Nucléaire*, **32**, 409-417. https://doi.org/10.1016/j.mednuc.2008.06.003

[30] Husarik, D.B., Miralbell, R., Dubs, M., John, H., Giger, O.T., Gelet, A., *et al*. (2008) Evaluation of [^{18}F]-Choline PET/CT for Staging and Restaging of Prostate Cancer. *European Journal of Nuclear Medicine and Molecular Imaging*, **35**, 253-263. https://doi.org/10.1007/s00259-007-0552-9

[31] Picchio, M., Giovannini, E. and Messa, C. (2011) The Role of PET/Computed Tomography Scan in the Management of Prostate Cancer. *Current Opinion in Urology*, **21**, 230-236. https://doi.org/10.1097/MOU.0b013e328344e556

[32] Afshar-Oromieh, A., Avtzi, E., Giesel, F.L., Holland-Letz, T., Linhart, H.G., Eder, M., *et al*. (2015) The Diagnostic Value of PET/CT Imaging with the ^{68}Ga-Labelled PSMA Ligand HBED-CC in the Diagnosis of Recurrent Prostate Cancer. *European Journal of Nuclear Medicine and Molecular Imaging*, **42**, 197-209. https://doi.org/10.1007/s00259-014-2949-6

[33] Ceci, F., Uprimny, C., Nilica, B., Geraldo, L., Kendler, D., Kroiss, A., *et al*. (2015) ^{68}Ga-PSMA PET/CT for Restaging Recurrent Prostate Cancer: Which Factors Are Associated with PET/CT Detection Rate? *European Journal of Nuclear Medicine and Molecular Imaging*, **42**, 1284-1294. https://doi.org/10.1007/s00259-015-3078-6

[34] Eiber, M., Maurer, T., Souvatzoglou, M., Beer, A.J., Ruffani, A., Haller, B., *et al*. (2015) Evaluation of Hybrid ^{68}Ga-PSMA Ligand PET/CT in 248 Patients with Biochemical Recurrence after Radical Prostatectomy. *Journal of Nuclear Medicine*, **56**, 668-674. https://doi.org/10.2967/jnumed.115.154153

[35] Gauthe, M., Belissant, O., Girard, A., Yin, J.Z., Ohnona, J., Cottereau, A.-S., *et al*. (2017) TEP/TDM et Recidive Biologique D'adenocarcinome Prostatique: Apport du ^{68}Ga-PSMA-11 Lorsque la ^{18}F-Fluorocholine N'est pas Contributive. *Progres en Urologie*, **27**, 474-481. https://doi.org/10.1016/j.purol.2017.04.004

[36] Perera, M., Papa, N., Christidis, D., Wetherell, D., Hofman, M.S., Murphy, D.G., *et al*. (2016) Sensitivity, Specificity, and Predictors of Positive ^{68}Ga-Prostate-Specific Membrane Antigen Positron Emission Tomography in Advanced Prostate Cancer:

A Systematic Review and Meta-Analysis. *European Urology*, **70**, 926-937. https://doi.org/10.1016/j.eururo.2016.06.021

[37] Verburg, F.A., Pfister, D., Heidenreich, A., Vogg, A., Drude, N.I., Vöö, S., *et al*. (2016) Extent of Disease in Recurrent Prostate Cancer Determined by [^{68}Ga] PSMA-HBED-CC PET/CT in Relation to PSA Levels, PSA Doubling Time and Gleason Score. *European Journal of Nuclear Medicine and Molecular Imaging*, **43**, 397-403. https://doi.org/10.1007/s00259-015-3240-1

[38] Zoungrana, M. (2022) Apport de la Scintigraphie Osseuse au MDP Dans le Bilan D'extension des Tumeurs de L'enfant au Service de Medecine Nucleaire du CHU Yalgado Ouedraogo: A Propos de 21 Cas Colliges de 2012 A 2020. Mémoire du Diplôme d'Etudes Spécialisées de Médecine Nucléaire, Université Cheikh Anta Diop de Dakar (Sénégal), No. 011, 90.

[39] Debiais, F. (2015) Donnees Epidemiologiques et Cliniques des Metastases Osseuses. *Oncologie*, **17**, 63-68. https://doi.org/10.1007/s10269-015-2488-1

[40] Paycha, F. and Richard, B. (2001) Exploration Scintigraphique du Squelette. Encyclopedie Medico-Chirurgicale, 30.

[41] Chaffer, C.L. and Weinberg, R.A. (2011) A Perspective on Cancer Cell Metastasis. *Science*, **331**, 1559-1564. https://doi.org/10.1126/science.1203543

[42] Giammarile, F. (2006) Bone Scintigraphy; La Scintigraphie Osseuse. Medecine Nucleaire Imagerie Fonctionnelle et Metabolique, 30.

[43] El Ajmi, W., Hmida, O.B., Limam, K., Hammami, H. and Sellem, A. (2020) Cancer du Sein en Tunisie: Profil Epidemiologique et Depistage des Metastases Osseuses. *Medecine Nucleaire*, **44**, 120. https://doi.org/10.1016/j.mednuc.2020.01.046

[44] Rajkumar, D., Singh, J. and Devasia, A. (2008) Superscan in Carcinoma Prostate. *The Indian Journal of Surgery*, **70**, 44-45. https://doi.org/10.1007/s12262-008-0012-1

[45] Soloway, M.S., Hardeman, S.W., Hickey, D., Todd, B., Soloway, S., Raymond, J., *et al*. (1988) Stratification of Patients with Metastatic Prostate Cancer Based on Extent of Disease on Initial Bone Scan. *Cancer*, **61**, 195-202. https://doi.org/10.1002/1097-0142(19880101)61:1<195::AID-CNCR2820610133>3.0.CO;2-Y