2021 International Nuclear Atlantic Conference – INAC 2021
Virtual meeting, Brazil, November 29 – December 2, 2021

ISBN: 978-65-594-1256-3

Comparison of 18F-FDG and 68-PSMA-11 in PET for prostate cancer diagnosis

Natalia Fernandes Fulle[1], and Gaianê Sabundjian[2]

[1]*natyffulle@usp.br, IPEN/CNEN - Av. Prof. Lineu Prestes, 2242 São Paulo – SP CEP 05508-000*
[2]*gdjian@ipen.br, IPEN/CNEN CNEN - Av. Prof. Lineu Prestes, 2242 São Paulo – SP CEP 05508-000*

1. Introduction

Cancer is one of the main causes of mortality worldwide, and is considered a global public health problem that has been generating a high economic and psychosocial burden [1]. The number of new cancer cases is directly related to the Human Development Index (HDI), and the number of cancer cases in countries with low and medium HDI, such as Brazil, is even more exacerbated [2, 3].
The Global Cancer Observatory (GLOBOCAN) provides updated estimates of the number of new cancer cases worldwide. In the year 2020 the number of cancer cases was 19.3 million, and the number of deaths was approximately 10 million people [1].
Due to the coronavirus pandemic (COVID-19) access to health services has been reduced, by the closure of many of these services, affecting the number of cancer diagnoses and treatments in the year 2020, this may increase the number of cases diagnosed in advanced stages in the coming years and consequently there will be an increase in the mortality rate [4].
Through the statistics and data provided by the National Cancer Institute (INCA) on the estimated number of cancer cases in Brazil for the triennium 2020-2022, it is estimated that 625 thousand new cases of cancer will occur, and the neoplasms that will most affect men with the exception of non-melanoma skin cancer, will be respectively: prostate (29.2%), colon and rectum (9.1%), lung (7.9%), stomach (5.9%) and oral cavity (5.0%); for women with the exception of non-melanoma skin cancer, breast (29.7%), colon and rectum (9.2%), cervix (7.5%), lung (5.6%) and thyroid (5.4%) cancers will have the highest incidence [5].
This work will focus on prostate cancer, because it is the fifth most recurrent neoplasm in the world and the second most incident in men. It is known that early diagnosis increases the chances of cure and enables a less aggressive treatment for the patient [6]. The Ministry of Health currently does not recommend national programs for prostate cancer screening in the country. There is guidance for performing exams such as rectal touch and Prostatic Specific Antigen (PSA) [7]. Nuclear medicine presents effective alternatives for prostate cancer diagnosis, such as Positron Emission Tomography (PET) or PET and Computed Tomography (PET/CT) imaging. This work will focus on the radiopharmaceuticals 18F-FDG and 68Ga-PSMA-11, which are the most widely used in routine PET/CT scans in nuclear medicine. The objective of this work is to compare the use of these radiopharmaceuticals in the diagnosis of prostate cancer by means of PET scans, addressing their advantages and disadvantages.

2. Methodology

The methodology used in this work consisted of a survey of data in the literature, comparing the advantages and disadvantages of the radiopharmaceuticals 68Ga-PSMA-11 and 18-FDG, which are currently the most widely used in Brazil for the diagnosis of prostate cancer with PET and PET/CT.
The results obtained are presented in the next item of this work

3. Results and Discussion

The radiopharmaceutical 68Ga-PSMA-11 has limitations such as its shorter half-life and the limited amount of doses produced when compared with 18F-FDG that can be produced in scale and has a longer half-life, making it possible to transport it to locations far from the production center [8].
Table I presents the advantages and disadvantages of using the 18F-FDG radiopharmaceutical, which is the most widely used in PET in Brazil. Table II presents the advantages and disadvantages of using the radiopharmaceutical 68Ga-PSMA-11 only in the diagnosis of prostate cancer through PET and PET/CT. In Brazil, this radiopharmaceutical has been used since 2015.

Table I: Advantages and disadvantages of the radiopharmaceutical 18F-FDG

Advantages	Disadvantages
It is the most widely used PET imaging diagnostic in oncology, because glucose metabolism is elevated in tumor cells.	Its accuracy in detecting prostate cancer is lower, due to the low metabolic rate of this type of tumor and its excretion through the urinary tract.
Its half-life of 109.7 min makes full body imaging possible.	Excretion through the urinary tract affects the identification of lesions in this region due to the proximity of the prostate to the bladder.
Despite its lower efficiency in diagnosing prostate cancer, studies show that 18F-FDG can influence the clinical management of patients with this type of cancer (from no treatment to treatment in 25% of the cases after PET scanning with 18F-FDG).	Prostate cancer tumor cells have a low glucose metabolism which makes it difficult to evaluate tumor cells from benign tissue or inflammatory lesions in the prostate (prostatitis).
In patients diagnosed with bone metastasis 18F-FDG can distinguish metabolically active from inactive lesions.	Low sensitivity in identifying bone and pelvic lymph node metastasis.
PET with 18F-FDG may be useful for staging advanced prostate cancer in patients with high PSA levels (despite treatment) and in patients without any treatment.	PET with 18F-FDG is not useful in the evaluation of advanced prostate cancer in patients who are on treatment and have a low PSA level.
	False positive results may occur in cases of prostatitis.
	High uptake in inflammatory cells and healthy organs can lead to false-positive results.

Source: According to references [9, 10, 11, 12, 13, 14, 15].

Table II: Advantages and disadvantages of radiopharmaceutical 68Ga-PSMA-11

Advantages	Disadvantages
When compared with conventional imaging techniques, PET/CT with 68Ga-PSMA-11 achieves a superior result in detecting cases of biochemical recurrence of prostate cancer.	Daily production limit, affecting the amount of exams performed.
The use of this radiopharmaceutical has a significant impact on the clinical management of patients with prostate cancer, as well as in cases of biochemical recurrence and pre-surgical staging.	High activity in the bladder and urinary excretion.
In advanced stage or metastatic patients, PET/CT with 68Ga-PSMA-11 has a high detection rate - 84% impacting clinical management by 61%.	Low image resolution due to the high energy of the emitted positron.
In patients who have an elevated PSA level even after treatment, PET/CT with 68Ga-PSMA-11 can assist in a change in treatment strategy.	
High benefit in the diagnosis of high-risk patients according to the D'Amico classification (PSA >20 ng/ml).	Little benefit in diagnosing low to intermediate risk patients according to the D'Amico classification (PSA <10 ng/ml to 20 ng/ml).

Source: According to references [16, 17, 18, 19, 20]

4. Conclusions

The radiopharmaceutical 68Ga-PSMA-11 has been used in recent years in PET for the diagnosis of prostate cancer. Compared to 18F-FDG, 68Ga-PSMA-11 has some advantages such as its availability by means of generators, the independent production of a cyclotron facility and its theranostic potential. The disadvantages compared to 18F-FDG are the scalability of 18F-FDG production compared to limited generator production; the ability to transport 18F-FDG to centers farther away from the production site as the shorter half-life of 68Ga limits distribution to sites closer to the production site, favoring in house production and the longer half-life of 18F allows for late imaging, which can increase the detection rate, and it is possible to increase imaging time.

The radiopharmaceutical 18F-FDG is the most widely used PET/CT in oncology. Despite its favorable characteristics, this radiopharmaceutical has limitations in the diagnosis of some types of tumors, such as prostate cancer, besides having a high uptake in inflammatory cells and healthy organs, which can lead to false-positive results. Despite its lower efficiency in diagnosing prostate cancer, studies show that 18F-FDG can influence the clinical management of patients with this type of cancer (from no treatment to treatment in 25% of the cases after PET scanning with 18F-FDG).

In recent years several studies have demonstrated the potential of the radiopharmaceutical 68Ga-PSMA-11 in the detection of relapses and metastases of prostate cancer.

As future work, the goal is to make a projection of the use of these radiopharmaceuticals for 2040.

Acknowledgements

To Instituto de Pesquisas Energética e Nucleares / Comissão Nacional de Energia Nuclear (CNEN) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPQ) for financial support – Brazil.

References

[1] CAO, Wei et al. Changing profiles of cancer burden worldwide and in China: a secondary analysis of the global cancer statistics 2020. Chinese Medical Journal, v. 134, n. 7, p. 783, 2021.

[2] SARACCI, R.; WILD, C. P. International Agency for Research on Cancer - The First 50. Lyon: IARC, 2015. Disponivel em: <http://www.iarc.fr/en/publications/books/iarc50/IARC_50%20years.pdf >. Acesso em: 16 jul. 2021.

[3] SUNG, Hyuna et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: a cancer journal for clinicians, v. 71, n. 3, p. 209-249, 2021.

[4] SIEGEL, REBECCA L. et al. Cancer Statistics, 2021. CA: a Cancer Journal for Clinicians, v. 71, n. 1, p. 7-33, 2021.

[5] INSTITUTO NACIONAL DE CÂNCER, 2020. Estimativa 2020. Disponível em <https://www.inca.gov.br/estimativa/introducao>. Acesso em: 25 mar. 2021.

[6] MINISTÉRIO DA SAÚDE. Secretaria de atenção à saúde. Departamento de ações programáticas estratégicas. Área técnica de saúde do homem. Política nacional de atenção integral à saúde do homem: princípios e diretrizes. Brasília: Ministério da Saúde, 92 p; 2009.

[7] PESQUISA DO INSTITUTO ONCOGUIA. Conhecendo a realidade dos pacientes com câncer de próstata, 2015.

[8] KESCH C, KRATOCHWIL C, MIER W, KOPKA K, GIESEL FL. 68Ga or 18F for prostate cancer imaging?. Journal of Nuclear Medicine, v. 58, n. 5, p. 687-688, 2017.

[9] ALMUHAIDEB, Ahmad; PAPATHANASIOU, Nikolaos; BOMANJI, Jamshed. 18F-FDG PET/CT imaging in oncology. Annals of Saudi medicine, v. 31, n. 1, p. 3-13, 2011.

[10] RUDROFF, Thorsten; KINDRED, John H.; KALLIOKOSKI, Kari K. [18F]-FDG positron emission tomography—an established clinical tool opening a new window into exercise physiology. Journal of Applied Physiology, v. 118, n. 10, p. 1181-1190, 2015.

[11] MORRIS, Michael J. et al. Fluorinated deoxyglucose positron emission tomography imaging in progressive metastatic prostate cancer. Urology, v. 59, n. 6, p. 913-918, 2002.

[12] SANZ, G. et al. Positron emission tomography with 18fluorine-labelled deoxyglucose: utility in localized and advanced prostate cancer. BJU international, v. 84, n. 9, p. 1028-1031, 1999.

[13] SUNG, J. et al. Fluorodeoxyglucose positron emission tomography studies in the diagnosis and staging of clinically advanced prostate cancer. BJU international, v. 92, n. 1, p. 24-27, 2003.

[14] HILLNER, Bruce E. et al. Relationship between cancer type and impact of PET and PET/CT on intended management: findings of the national oncologic PET registry. Journal of Nuclear Medicine, v. 49, n. 12, p. 1928-1935, 2008.

[15] JACOBSON, Orit; KIESEWETTER, Dale O.; CHEN, Xiaoyuan. Fluorine-18 radiochemistry, labeling strategies and synthetic routes. Bioconjugate chemistry, v. 26, n. 1, p. 1-18, 2015.

[16] CALAIS, Jeremie et al. Impact of 68Ga-PSMA-11 PET/CT on the management of prostate cancer patients with biochemical recurrence. Journal of Nuclear Medicine, v. 59, n. 3, p. 434-441, 2018.

[17] SONNI, Ida et al. Impact of 68Ga-PSMA-11 PET/CT on staging and management of prostate cancer patients in various clinical settings: a prospective single-center study. Journal of Nuclear Medicine, v. 61, n. 8, p. 1153-1160, 2020.

[18] ALBISINNI, Simone et al. Clinical impact of 68Ga-prostate-specific membrane antigen (PSMA) positron emission tomography/computed tomography (PET/CT) in patients with prostate cancer with rising prostate-specific antigen after treatment with curative intent: preliminary analysis of a multidisciplinary approach. BJU international, v. 120, n. 2, p. 197-203, 2017.

[19] KUTEN, Jonathan et al. Head-to-head comparison of 68Ga-PSMA-11 with 18F-PSMA-1007 PET/CT in staging prostate cancer using histopathology and immunohistochemical analysis as a reference standard. Journal of Nuclear Medicine, v. 61, n. 4, p. 527-532, 2020.

[20] RAUSCHER, Isabel et al. 68 Ga-PSMA ligand PET/CT in patients with prostate cancer: How we review and report. Cancer Imaging, v. 16, n. 1, p. 1-10, 2016.