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Technical Requirements of PET Systems for Assessing Gynecological Cancers

Abstract

The International Federation of Gynecology and Obstetrics has recognized the benefits of using Positron Emission Tomography (PET) imaging in the detection, stage evaluation and follow-up of gynecological cancers (GCs). However, conventional state-of-the-art PET scanners offer low sensitivity and non-uniform spatial resolutions which are insufficient for the correct diagnosis of onco-gynecological lesions.

Extending the use of PET in the gynecological practice requires the development of patient-adaptable scanners able to provide photon depth of interaction (DOI) information for 3D positioning of the events, time-of-flight (TOF) capabilities and high sensitivity. In addition, the equipment must achieve homogeneous spatial resolutions < 2 mm in the entire field-of-view (FOV), better image contrast and, be affordable. The inclusion of such a dedicated PET equipment in gynecological oncology will impact the socio-sanitary field since better image quality enables for better diagnoses, which is a key factor in the recovery and life expectancy of patients.

In this review, each of these points are studied, delving into the impact of PET imaging for GCs assessment and how may contribute improving diagnostic and therefore patient recuperation. The present article begins introducing GCs and its incidence in our society. This is followed by a description of the basic concepts underlying PET imaging, the historical facts that contribute to its development and, the main components typically encountered in PET detectors. Then, a revision of the state-of-the-art PET technology is provided highlighting the main limitations encountered for accurate diagnoses of onco-gynecological lesions and, the requirements to overcome them. Finally, some hints regarding the most suitable scanner design for the detection, assessment and follow-up of gynecologic oncology patients is offered.

Review Article

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Introduction

The present work provides insights on Gynecological Cancers (GCs) and describes the basic concepts underlying Positron Emission Tomography (PET) imaging. The introduction section provides a description of the historical facts that have contributed to its development as well as of the main components typically encountered in PET detectors.

Gynecological cancers (GCs)

According to the National Cancer Institute, the word cancer is used to designate diseases in which cells divide without control and invade, in some cases, nearby tissues and/or

spread to other parts of the body (metastatic cancer) [1]. Human cells grow and multiply to form new cells as the body needs them. When cells get old or become damaged, they die, and are replaced by new ones. Occasionally, the genes that are responsible of managing cell activity mutate and create abnormal cells that divide and multiply without control and, eventually form tumoral lesions that can be either malign (cancerous) or benign (not cancerous). Thus, cancer is considered a genetic disorder that may disrupt the human body functions [2].

Nowadays, cancer constitutes one of the major health concerns all over the world, with approximately 19.3 million cancer cases and 11.0 million cancer-related deaths in 2020, represent one of the major problems facing humans. Cancer may appear anywhere in the human body, being the most common one Breast Cancer reporting 287,850 of annual cases, followed by lung cancer with 2,206,771 of annual cases and approximately 350 deaths per day (the deadliest cancer), and then, colorectal cancer with 1,931,590 of annual cases [3]. Regarding Gynecological Cancers (GCs) which are the target of this review, account for 19% of the 5.1 million new cancer cases, causes 2.9 million deaths worldwide per year [4], and has a survival rate for five years of 44%.

GCs refers to any cancer that originates in the woman reproductive organs, six main GC types can be distinguished [5], namely: ovarian, cervical, vulvar, vaginal, uterine and fallopian tube cancer. Each gynecologic cancer is unique, with different symptoms, different prevention strategies and, distinctive risk factors (things that may increase your chance of developing cancer or other malignancies) being the main ones the family medical record, obesity, age and Human Papillomavirus (HPV) antecedents. Table 1 summarizes the signs and symptoms of these cancers [6] and, Figure 1 left provides information regarding women gynecological anatomy.

Note that all women are at risk for GCs, indeed GCs are a major health concern since approximately every 6 minutes a woman is diagnosed with a GC.

Regarding diagnosis, many tests are performed to determine whether a person has cancer, or a different condition such as infection. Since the stage of the cancer at the moment of diagnosis may dictate the prognosis of the patient, it is mandatory to provide effective, reliable and fast response [7]. Diagnostics impact almost all key decision along the patient journey and dictates the most

Ovarian	Vaginal	Vulvar	Endometrial	Cervical
Bleeding between menstrual cycles	Postmenopausal bleeding	Postmenopausal bleeding	Postmenopausal bleeding	Postmenopausal bleeding
Bloated or swollen abdomen	Vaginal mass	Painful ulcer or mass on external genitals	Heavier and/or longer menstrual bleeding	Vaginal bleeding not related with the menstrual period
Pain and/or mass in pelvic area	Pain and/or bleeding during/after intercourse	Itching and/or pain on external genitals	Pain and/or mass in pelvic area	Pain and/or bleeding during/after intercourse
Gas, indigestion and nausea	Pelvic pain and constipation	Irregular Bleeding between menstrual cycles	Irregular Bleeding between menstrual cycles	Watery of foul-smelling discharge
Loss of appetite	Difficulty urinating	Change in skin color of external genitals	-	-
Frequent urination	-	-	-	-

Table 1. Summary of the signs and symptoms of GCs cancers.

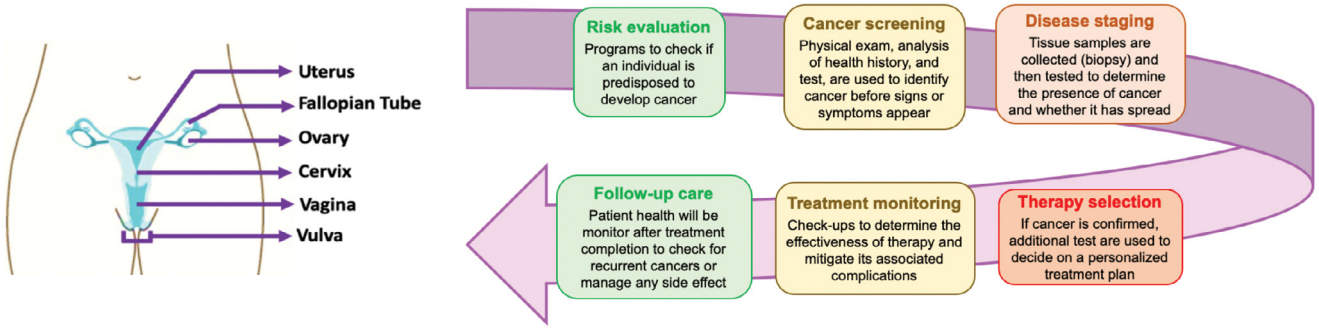

Figure 1. Left, women gynecological anatomy. Right, flow chart usually employed for assessing cancer.

suitable treatment [8-10]. Figure 1 right, exemplifies the flow chart usually followed for cancer diagnosis.

As mentioned, treatment is most effective when cancer is diagnosed early and thus, the need for an effective diagnostic imaging tool is evident. In this regard, PET has proven superior to other conventional imaging techniques [11]. However, commercial PET scanners result in a limited spatial resolution, and have low sensitivity for GCs [12], as discussed in the following section.

Positron Emission Tomography (PET) imaging

PET imaging has consolidated as the imaging technique of excellence for the diagnose, monitor and therapy follow up of a large variety of cancers, neurodegenerative diseases and other medical conditions [12].

PET imaging is based on the positron-electron annihilation principle and the subsequent coincidence detection of the two resulting 511 keV annihilation photons. The PET imaging process starts with the injection of a radiotracer compound in the patient body. Radiotracers are chemical compounds, similar to naturally occurring substances in the body, in which one or more atoms have been replaced by positron-emitting radionuclides. The radiotracer decay emitting positrons, which randomly travel inside the patient body until colliding with a cortical electron of the tissue and, as a result, emit two 511 keV gamma-rays in almost opposite directions. These two 511 keV gamma-rays have enough energy to escape from the patient's body and to interact with two detectors of the PET scanner [13]. The detection of the two 511 keV gamma-rays within a predefined time windows (in the order of few nanoseconds) is called coincidence detection and each coincidence event is assigned to a line of response (LOR) which is the line joining the two detectors involved. Note however that due to both physical effects and the coincidence detection method, the assigned LOR may not coincide with the actual position of the emitted positron and therefore, the image quality may be degraded [14]. Finally, after collecting enough coincidence events, complex reconstruction algorithms are employed to generate an image showing the 3D distribution of the radiotracer in the subject. Figure 2 shows a schematic representing the main steps followed in PET explorations.

To collect as many coincidence events as possible, PET systems are usually constructed using several detectors arranged in a ring that surrounds the patient body [15]. PET detector blocks have to be designed and optimized for the efficient stopping and detection of the incoming high energy radiation (511 keV) to provide an accurate estimation of the 3D photon impact coordinates within the scintillation crystal, the deposited energy and, the photon time of flight (TOF). Regarding the detector design, three main components are distinguished (see zoomed orange box in Figure 3):

i) Scintillation block: is responsible for stopping the 511 keV annihilation photons generating as a consequence, many optical photons of lower energy (in the eV range). Inorganic scintillation materials are more suitable to stop these gamma-rays and therefore, are the ones typically used in PET scanners [16]. Different crystal geometries are available such as pixelated, monolithic and, semi-monolithic crystals.

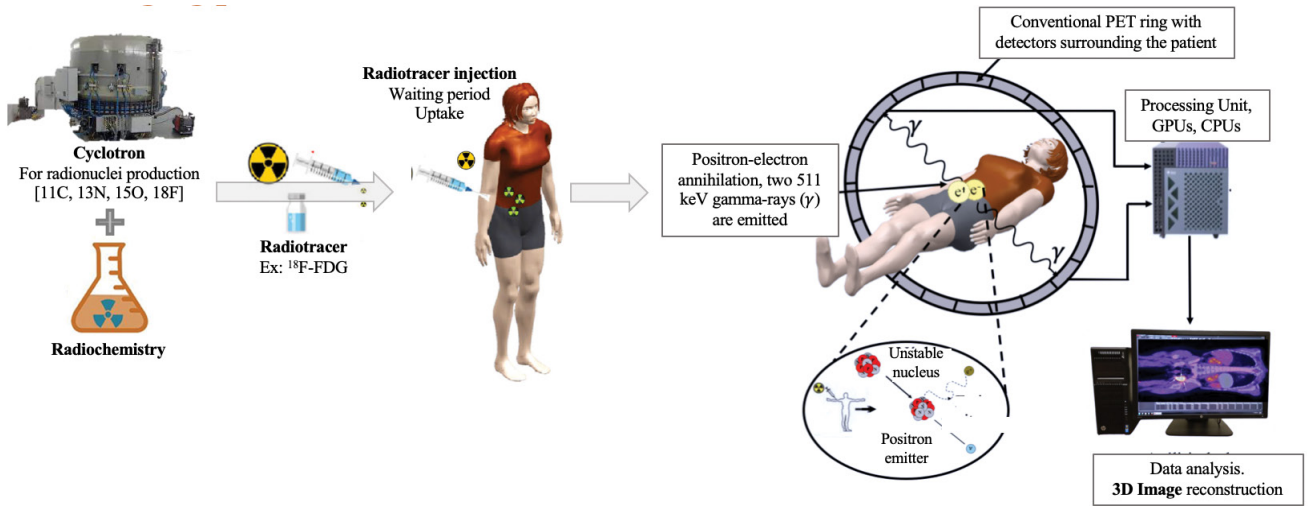

Figure 2. Schematic representing the main steps followed in PET exam. The process starts with the production of the radionuclei and continues with the synthesis of the specific radiotracer. Then, the radiotracer is injected into the patient and, after a determined period of time of usually 30-90 min the PET scan is performed.

ii) Photodetector (or photosensor): has to efficiently convert the low signal coming from scintillation photons into electrical signals, this property is called Photon Detection Efficiency (PDE) and should be as high as possible [17]. The photodetectors of choice for gamma-imaging are photomultiplier tubes (PMTs) and Silicon Photomultipliers (SiPMs).

iii) Readout and front-end electronics: for shaping and processing the output signals coming from the photodetectors. These signals (analog or digital) are fed into the Data Acquisition System (DAQ) to be shorted by coincidences and later digitized. An alternative element using digital information is Application Specific Integrated Cirtuits (ASICs) [18].

The combination of the above-mentioned elements should maximize the detector block performance, providing high photon absorption efficiency of the 511 keV photons and exhibit good spatial, energy and time resolutions. The photon absorption mainly relies on the scintillator block type, higher photo absorption is accomplished using high Z_{eff} scintillator materials which, in addition, leads to a higher fraction of photoelectric interactions (lower fraction of scattered events) and thus, to a higher signal to noise ratio (SNR) in the reconstructed images [16]. With an optimal selection of the components high efficiency PET scanners have become available and, constitute the most widely used molecular imaging technique in the clinical field and also in preclinical research. However, reaching this level of performance has not been easy, indeed the development of PET is plenty of milestones, being the main historical facts that have contributed to its development summarized in the following:

1929, Theoretical prediction of the positron by Dirac [19]

1932, Experimental discovery of the positron by Anderson [20]

1934, Discovery of radioactive elements by Curie y Joliot

– First use of a cyclotron to generate artificial radionuclides at the University of California Berkeley [21]

1945, First use of radiotracers in humans [22]

1948, Detector improvements: launch of the PMT. First detectors were based on big cylinders of NaI(Tl) scintillators coupled to big PMT, poor resolution.

1952, Brownell y Sweet (MGH), proposed for the first time to use radiation for the visualization and treatment of tumors [23]

1953, Construction of the first PET. This scanner was dedicated to brain studies [24,25]. Figure 4.a shows an example of the PET images obtained at that time

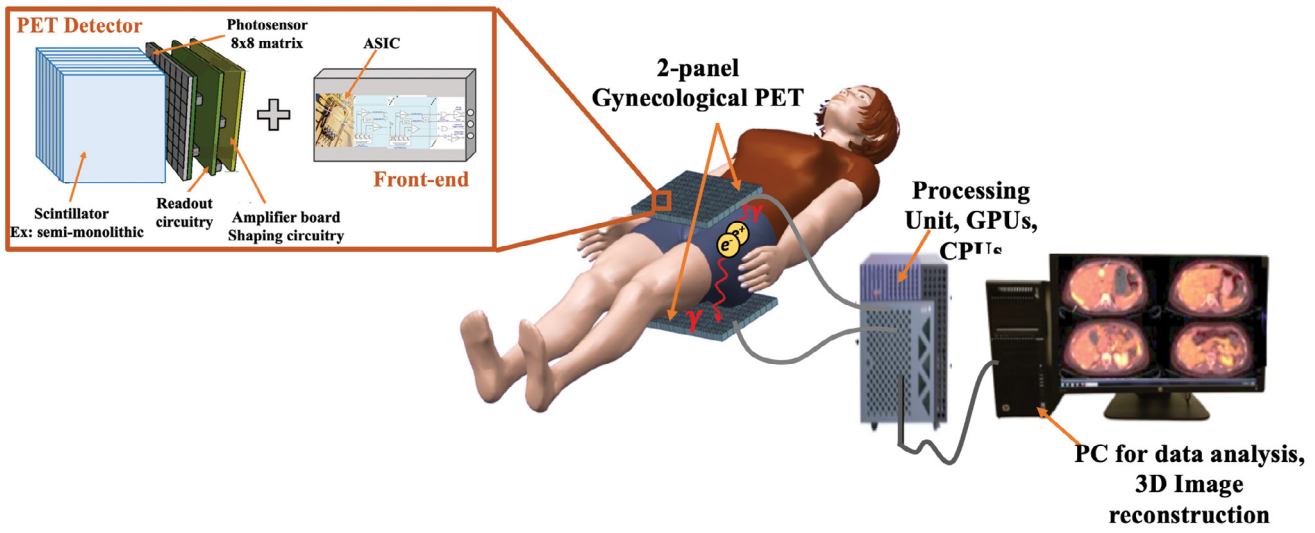

Figure 3. Example of a potential geometry for a Gynecological PET system based on 2-panles. The orange box zooms a detector block and included labels to its main components, namely: scintillator, photosensors, readout, and front-end electronics.

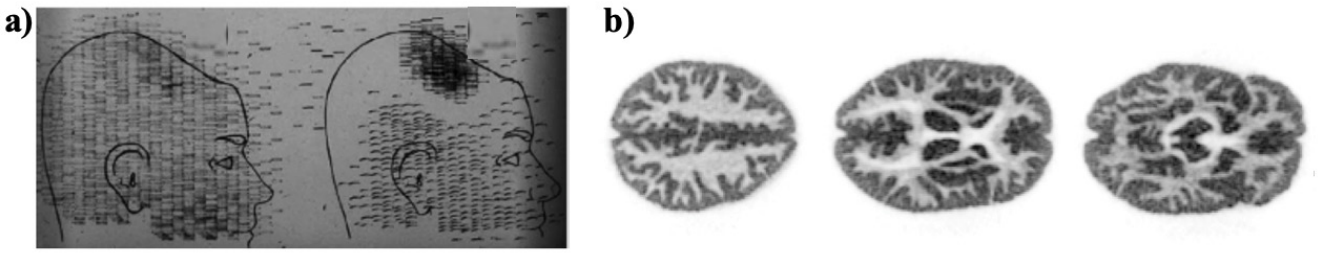

Figure 4. Brain PET images obtained with **a)** the first PET scanner, the POSITOME (1953); **b)** state-of-the-art clinical system (2022).

Up to this point it was mandatory to enhance the accuracy of the images to extend the use PET thus, research focused on the development of new and improved detector technology:

1970, Robertson and Thompson constructed the first completed PET scanner: The Positome

1978, Synthesis of new radiotracers ^{18}F-FDG. Since then FDG is the most commonly used tracer in oncology [24]

1990, Appearance of new scintillators such as BGO and LSO [26]. These crystals were produced in smaller sizes (better resolution) and provided improved performance since they have higher light yield and faster response than NaI(Tl)

– Implementation of novel readout topologies such as the Anger Logic to boost photon positioning [27]

1993, The improved resolution motivated for the construction of pre-clinical PET systems for research with animals [28]

2000, The photodetector technology evolved and solid-state detectors appeared such as the SiPMs which present advantages over PMTs (more compact, lower bias Voltage, larger market of suppliers, compatibility with magnetic fields…)

– This improved technology combined with the implementation of accurate algorithms and data processing methods enabled to include time-of-flight (TOF) and depth of interaction (DOI) capabilities during the reconstruction process yielding to high-quality PET images [29]

2010, Introduction of Artificial Intelligence algorithms in PET imaging for event positioning and classification, calibration processes correction or image reconstruction, among others [30]. See Figure 4.b for an actual PET image of a human Brain.

In the present time, the scintillation and photosensor technology still continue evolving. Regarding the readout, analog and ASICs circuits are being extensively studied to provide improved design that may allow for compact and high-performance PET scanners with large volume of materials and thus large number of output signals that need to be properly characterized by the data acquisition system (DAQ). Moreover, intense research and advancements are being done in the reconstruction area. With all these factors high-performance scanners are available now but still, more technological breakthroughs need to be achieved for boosting the use of PET in gynecology.

Materials & Methods

State-of-the-art PET scanners

State-of-the-art PET systems are an indispensable tool for the diagnostic of tumoral lessions and other malignancies. Four different categories of PET scanners can be distinguish based on its geometrical design, axial and transaxial dimensions and the target application, namely:

i) Total-Body (TB) PET: report the highest sensitivity since present the longest axial coverage (up to 2m long). However, building such a large system imposes major technological challenges, higher production cost and complex hardware which constrain its transference to the clinics.

ii) Whole-Body (WB) PET: these scanners have axial lengths in the range of 15-32 cm and are the ones routinely used in the clinics. Despite WB-PET is the most used imaging system in nuclear medicine, technological advancements are still required to fully exploit their capabilities.

iii) Organ-dedicated PET: present alternative geometries to the cylindrical one and compact design that allows placing the detectors closer to the area under study thus enabling high sensitivity while providing improved image contrast recovery, and also lower cost. The main drawback is that these scanners focus in only one organ or area.

iv) Pre-clinical PET: these systems are optimized in terms of spatial resolution since are used in research with small animals in which the lesions and organs are small.

Table 2 reports the main performance parameters of some of the WB-PET scanners that are used in the clinics, also, these parameters are reported for the only commercially available TB-PET scanner. As can be seen, the specifications of conventionally used WB-PET scanners (which are the ones used in the clinics worldwide) in terms of spatial resolution are not optimized for visualizing small structures since report values of ~3-5 mm at the center of the scanner field of view (FOV), further degrading (due to the lack of DOI capabilities) up to 6 mm towards the edges. Moreover, and despite being the most sensitive molecular imaging technique, state-of-the-art PET scanners present low sensitivity of only ~1%, which implies injecting high amount of radiotracer dose to the patient as well as long scanning times thus reducing patient throughput. Also, the geometry of these scanners makes it impossible for the physician to intervene the area under study during PET imaging. Thus, these scanners are not optimized for visualizing the small lesions typically encountered in prostate, gynecology (see next section) or brain cancers, among others, which compromises the diagnostic and patient outcomes. Therefore, there is a huge interest on further improving current technology to enhance diagnostic through PET imaging.

Table 3 reports the performance parameters of interest achieved by organ-dedicated and pre-clinical systems. As can be seen, these dedicated systems provide better spatial resolution, in the range of ~1.4-4 mm, than WB-PET. Moreover, in some of them, these value remains almost constant across the entire FOV since they include DOI capabilities and thus, provide enhanced diagnostic for lesion in the peripheral areas. It should be mentioned that the only (no more than 2 or 3 systems) clinically available organ dedicated systems focus in breast and brain imaging, and there are only a couple of organ-dedicated prototypes being investigated for prostate and heart studies. Nevertheless, up to date, there is no PET system dedicated to the study of the GCs which will be of major interest.

System	Geometry	Detector	Spatial Res.	DOI	TOF
Siemens Vision PET/CT	Ring	LSO pixelated Analog SiPMs	3.7 mm	No	178 ps
GE Discovery MI PET/CT	Ring	LYSO pixelated Analog SiPMs	4.3 mm	No	382 ps
Philips Vereos PET/CT	Ring	LSO pixelated Digital SiPMs	4.24 mm	No	310 ps
Canon Cartesian PET/CT	Ring	LYSO pixelated Analog SiPMs	-	No	255 ps
United Imaging PET/CT	Ring	LYSO pixelated Digital SiPMs	2.98 mm	No	372 ps

Table 2. Performance parameters of some of the WB-PET scanners and a TB-PET system.

System	Application/ Organ	Detector	Spatial Res.	DOI	TOF
PEM-Flex	Breast	Pixelated Analog SiPMs	< 2.0 mm	No	No
MAMMI	Breast	LYSO monolithic Analog SiPMs	1.8 mm	4.0 mm	No
CareMiBrain	Brain	LYSO monolithic Analog SiPMs	1.4 mm	<3 mm	No
Helmet-Type	Brain	Pixelated Analog SiPMs	3-4 mm	7.5 mm	No
Albira	Preclinical	LYSO monolithic Analog SiPMs	<0.7 mm	2.5 mm	No
DigyPET	Preclinical	LYSO pixelated Digital SiPMs	0.7 mm	2 mm	No
β-cube	Preclinical	LYSO monolithic Analog SiPMs	0.8 mm	1.6 mm	No

Table 3. Performance parameters of organ-dedicated and pre-clinical PET scanners.

Limitations and requirements of PET for GCs

The International Federation of Gynecology and Obstetrics (FIGO) classification recognizes the limitations of anatomic cross-sectional imaging in evaluating the extent of GCs but, highlights the benefits of preoperative imaging assessment using PET such as improved detection, stage evaluation and follow-up of these cancers.

Until recently, FDG-PET have had a key role in the diagnosis and staging of disease in GC patients. FDG is the most common molecule used in PET, mainly synthesized by glucose with a ^{18}F (positron emitter) radical. But, its lack of specificity leads to inaccurate diagnoses. For example, gynecological malignancies typically present an increased glucose metabolism and therefore large FDG uptake, whereas benign tumoral lesions are usually negative on PET. Though, common drawbacks include increased FDG uptake in normal ovaries during ovulation, as well as normal physiologic activity in bowel, endometrium, and blood vessels, focal retained activity in ureters, bladder, pelvic kidneys, and urinary diversions. This produces false-negatives and compromise diagnostic and patient recovery. Therefore, to overcome these difficulties, it is convenient to co-registrate PET with, for example, computed tomography (CT) image.

Indeed, hybrid PET/CT imaging is considered a standard practice in the staging, treatment response, recurrent disease and follow-up of numerous GCs primary malignancies.

Promisingly, recent developments of gynecological-specific radiotracers, such as ^{68}Ga-FAPI, have shown promising results for extending the use of PET in GC. This radiotracer is more specific than FDG since the fibroblast activation protein (FAP) is a type II serine protease expressed by cancer-associated fibroblasts (CAFs), which are part of the stroma in many gynecologic tumors. The new options provided by these radiotracers has promoted the interest in using PET imaging for the quantification and localization of GCs.

However, as mention in the previous section, conventional state-of-the-art PET scanners (WB-PET) offer low sensitivity (<1%) and insufficient spatial resolutions (in the

range of 3-4 mm at the center and, up to 6 mm toward the edges of the FOV) for the correct diagnosis of onco-gynecological lesions. Therefore, extending the use of PET in gynecological practice requires to develop novel PET instrumentation, being the most suitable PET option building an organ-dedicated PET scanner that focusses on the gynecological area.

The gynecological-PET system has to provide high-performance and be cost-effective. Moreover, to improve the diagnoses and staging of GCs these novel systems should target on the following features:

i) Patient adaptable design; the optimal geometry for a gynecological dedicated PET have to be determined as the best trade-off between system performance and patient ergonomics. An alternative to conventional ring-shaped PET designs is an open-system constructed with two panels (flat or curved) with an adjustable distance between them to account for different patient sizes and clinical necessities [30]. This mechanical design may allow placing the detectors as close as possible to the area of interest thus improving sensitivity, while permitting the physician to intervene if necessary (for example, to perform guided biopsies). Eventually, this PET design could also be used in the surgery room due to its small design and high sensitivity (low doses to patient and clinicians). Figure 3 provides an example of a 2-palnel based gynecological PET.

ii) TOF capabilities; to precisely determine the time difference of the two detected photons in coincidence and therefore, boosting effective sensitivity. Implementing TOF information during the image reconstruction process will account for the lack of angular coverage and will reduce the noise levels improving the image Signal-to-Noise ratio (SNR) and thus, boosting sensitivity. Based on previous studies, < 200 ps timing resolution should be an optimal value for dedicated scanners.

iii) Uniform and improved spatial resolution; values below 2 mm across the entire FOV and, superior image contrast to allow a better diagnosis or treatment assessment. Achieving uniform spatial resolution requires an accurate characterization of the 3D photon impact position thus, DOI capabilities are required.

iv) High sensitivity to reduce the dose allowing for screening techniques or, to reduce scanning times to minimize motion artifacts or, a compromise between both; As mentioned, the sensitivity of conventional PET scanners is limited to ~1%. The main paths proposed to increase the physical sensitivity of PET scanners are: using thicker and denser crystals to boost the collection of annihilation photons, increasing the scanner axial length of the scanner (TB-PET), placing the detectors closer to the area under study (organ-dedicated PET), and improving the coincidence time resolution (CTR) of the detectors.

v) Be affordable to facilitate the translation of the technology to the clinics and its co-registration with an already existing CT scanner.

An optimal PET design for GCs

Considering all previous requirements and based on the recent studies, the most efficient detector design for building a gynecological PET scanner will make use of SiPM photosensors, semi-monolithic fast scintillators (to take advantage of both pixelated and monolithic crystals) and specific ASIC based readout electronics, see zoomed orange box in Figure 3. The semi-monolithic scintillator consists on a crystal geometry in which one side resembles a pixel and the other a monolithic block. While the monolithic direction grants direct access to the DOI information, which is key to provide uniform image resolution; the pixelated dimensions may allow us to reach accurate TOF. Moreover, this crystal geometry, combined with a dedicated readout system and advanced signal processing algorithms (i.e., neural networks (NN)), may allow to individually resolve multiple interactions (Compton and Photoelectric) in the detector per event if they occur in different crystals. Regarding the panel size and geometry: flat or curved panels, it should be determined as a result of anthropomorphic studies of females to make the design compatible with most of the population.

In addition to the detector technology, the development of a high-performance DAQ is mandatory. One solution may be a DAQ system based on modular readout electronics to process the information for each event. The detector blocks will be connected to a Concentrator Board (CB) and a Synchronization Board (SB) to provide a stable clock

reference for the detectors. The SB includes and FPGA that will receive the trigger from the CBs, which can be either the logic OR between the photosensor modules connected to each CB.

The last step to provide accurate reconstruction images, is the implementation of precise detector and system calibration methodologies and efficient reconstruction algorithms. Regarding calibration, these can be based either on traditional methods (complex software processes) or on NN ensembles. Using NN may accelerate the process since the calibration maps for the estimation of the 511 keV photon impact position within the crystals could be performed using simulated data for training thus avoiding the requirement of experimentally acquiring data for each detector. Once calibrated, the reconstruction of the image by including TOF and DOI information as well as all other needed corrections (dead time, random events, attenuation, normalization, etc) will be performed.

The development of such a system will improve state-of-the-art PET imaging by designing an organ-specific PET scanner for GC patients. The main expected results are described in the following.

Results

Outcomes of the new proposed technology

Gynecological-dedicated PET scanners are required to improve early detection and follow-up of GCs. As a technological outcome, the development of an improved state-of-the-art PET imaging design targeting on GCs patients will provide technology able to increase sensitivity for the detection of the small lesion with low uptake values, provide uniform spatial 3D resolution of 1-3 mm in the entire FOV of the system and accurate DOI resolution to also correct for the parallax error and thus better identify lesions at the peripheral areas of the body, and a variable distance between panels to account for different patient sizes thus, providing an individualized assessment. As a result, an enhancement in the early diagnose of GCs should be achieved, with the consequence of an improved patient management and enriched life expectancy.

In addition to the technical achievements, such a system will provide other relevant outcomes in terms of medical breakthroughs and social relevance, as listed below:

i) Enhanced image quality for GCs diagnosis and therapy assessment. This is a key factor determining the patient recovery and life expectancy. The proposed design will boost sensitivity (and most likely specificity) allowing to study small or very new tumoral masses. Moreover, an accurate determination of the lesion borders will be helpful for guiding surgical procedures such as tumor removal.

ii) Robust readout electronic chain for a reduced number of channels (multiplexing schemes) preserving high spatial sampling and accurate timing (ASIC). The multiplexed technology may enable the collection of a large number of output signal without compromising system performance and production costs.

iii) TOF capabilities while keeping good 3D positioning. Achieving <200 ps in a system imposes a new milestone in TOF-PET research since may allow to constrain the LOR to < 1.5 cm thus reducing the amount of statistic required. In addition to an increased system effective sensitivity, this achievement opens the way for spreading limited angle tomography scanners as well as the implementation of new PET designs without compromising the overall imaging performance.

iv) The novel system architecture allows for an easy installation in the clinical site. The system can be moved to the patient room in case the patient mobility is compromised. The design can be used for the study of other cancer types or for the identification of sentinel nodes and, in other research areas such as preclinical imaging. Moreover, the open geometry may allow the physician to practice interventions during data acquisition such as image guided biopsies to enhance cancer identification and staging as well as treatment planning.

v) Reaching high sensitivity, its superior effective sensitivity may allow to reduce the dose injected to the patient, but also to the clinical personnel. Similarly, the high sensitivity can be used to reduce the scanning times, therefore minimizing motion artifacts and increasing patient's throughput.

Considering the above-mentioned scientific milestones, we also expect a high socio-sanitary impact since the better image quality may enable for better diagnoses, which is a key factor in the recovery and life expectancy of patients.

From the social point of view, the device will improve the post-operative prognosis and the life quality of patients, it will reduce stress (and risks) generated if the patient must undergo a second intervention (highly expensive). Also, it is expected to reduce mortality by reducing positive margins and persistence of residual tumor. The usefulness of such a scanner covers most body shapes and patients of all ages. Regarding the healthcare system, the scanner will save intervention time and provide medical personnel with a greater operational vision. Moreover, will allow for new studies, research and clinical trials that required such a resolution.

Figure 5 provides a summary of the main technical performance breakthroughs and the socio-sanitary impact that may be accomplish by successfully building a gynecological PET system such as the proposed one.

Conclusion

Recent investigations have demonstrated the significant impact that PET imaging can have on GC patient management, since its use can improve staging, influence patient selection for therapies and detect early recurrent disease. However, commercial PET scanners offer relatively low sensitivity and limited spatial resolutions, making it difficult to visualize cancerous lesions thus compromising the diagnostic quality.

Therefore, there is considerable interest in developing an accurate, non-invasive imaging procedure to assess the disease staging and determine the optimal treatment. New PET imaging systems meeting the above-mentioned requirements should be investigated to improve the diagnosis of GCs, facilitate the early detection and treatment of these malignancies thus enhancing the life quality of patients.

In addition, such a system will surpass current state-of-the-art PET technology while helping the comprehension of certain GCs pathologies and to monitor the treatment effectiveness.

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Conflict of Interest

None to report. The authors declare that they have no known competing financial interests or personal relationships to disclose, that could have appeared to influence the work reported in this paper.

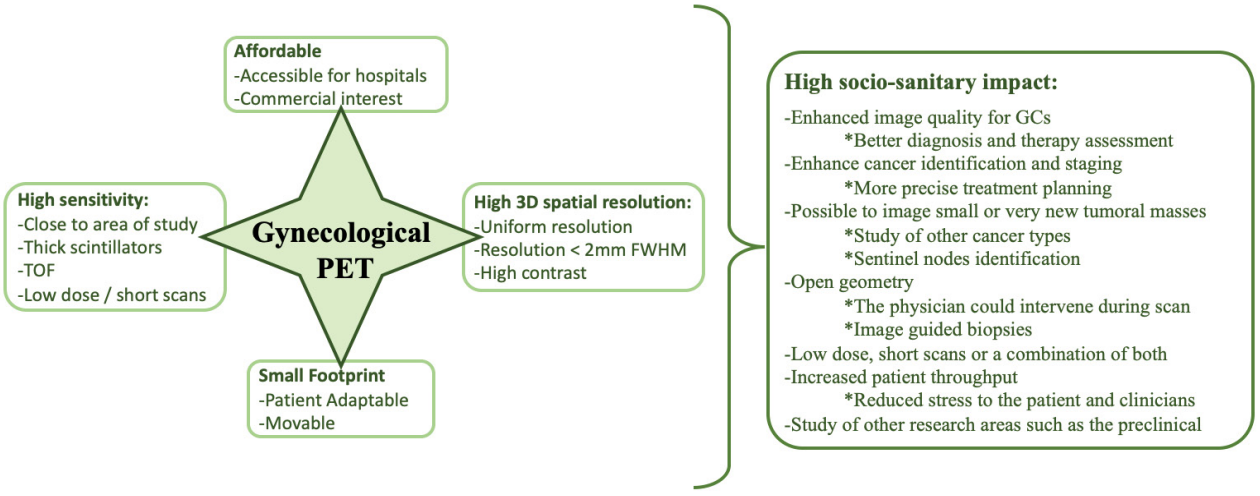

Figure 5. Summary of the main technical performance breakthroughs and the socio-sanitary impact that may be accomplish by successfully building a gynecological PET system.

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