Stereotactic Partial Breast Irradiation with GammaPod™ System: Technical and Clinical Workflow Implementation at IRCCS Pascale

Gennaro Gentile[1]

1. *Department of Radiation Oncology, Istituto Nazionale Tumori- IRCCS Fondazione G. Pascale, Naples, Italy*

* Corresponding author: gennaro.gentile1994@libero.it

KeyWords:
GammaPod; Stereotactic Partial Breast Irradiation(S-PBI); Cobalt-60; Radiotherapy workflow; Radiation; Therapist Technologist (RTT) role;Treatment Planning; Patient positioning; Quality Assurance; Multidisciplinary Oncology care;

Abstract

The integration of GammaPod™ technology at the IRCCS Fondazione Pascale in Naples represents an innovative breakthrough in the field of ultraselective breast radiotherapy (S-PBI). Designed for early-stage breast cancer, the device uses 25 rotating Cobalt-60 (60Co) sources with very high dose gradient collimation. The present study analyzes the clinical and organizational impact of the equipment, focusing on the operational workflow of the Radiation Therapist Technologist (RTT), the sizing and selection phases of the vacuum Breast Cup, organ dosimetry and the strategic positioning of the institute in the international scientific panorama. The prone approach and vacuum immobilization cancel respiratory movements, ensuring sub-millimeter precision. The dose to the heart (average < 0.5 Gy) and ipsilateral lung (V20Gy < 1.5%) is significantly reduced compared to conventional LINACs. The integrated workflow reduces the overall duration of treatment and skin exposure. The adoption of the system standardizes the operating practice by eliminating skin tattoos and positions IRCCS Pascale as a reference Hub in Southern Europe and an active member of the International Clinical Consortium

INTRODUCTION

Conservative treatment of breast cancer has evolved radically towards Partial Breast Radiation Therapy (PBI) [1]. The GammaPod™ system represents the first stereotactic platform dedicated exclusively to breast disease, designed to deliver high doses in single or ultra-hypofractionated fractions (1 –5 sessions) with sub-millimeter precision.

Unlike traditional Linear Accelerators (LINAC), GammaPod™ reduces residual doses to surrounding healthy tissues thanks to the combination of three key factors: the prone positioning of the patient, the mechanical isolation of the gland and the hemispherical focusing of 25 radiant beams.

The objective of this work is to describe the operational and technical-clinical workflow of the GammaPod™ system, evaluating the impact of the standardization of positioning conducted by the RTT and the dosimetric saving performance on organs at risk (OAR) Tab.1.

The success of stereotactic radiotherapy with GammaPod™ depends to a large extent on the accuracy of the workflow performed by the Radiation Therapist Technologist (RTT).The procedure eliminates the use of traditional skin tattoos, replacing them with a rigid mechanical reference at stereotactic spherical coordinates [2].

One of the most interesting features of the GammaPod™ technology is the integrated path:

IMMOBILIZATION → 2 CT ACQUISITION → 3PLANNING →4 TREATMENT

The sequence is particularly important to understand the role of the Radiation Therapist Technologist (RTT) Tab.2

Table 1 *Main Features Gammapod Technology*

25 Spherical CO-60 sources	**1-5 Sessions Treatment protocol**	**<1 mm Sub-millimiter accuracy**	**70% Reduction in Heart and Lung dose**

Table 2 *Workflow and role of the RTT*

Workflow phase	RTT Operational Description
1 . Prep & Sizing (Cup Fitting)	Patient reception, consent verification, selection and placement of Breast Cup with empty aspiration.
2. Loader Setup (CT Scanning)	Patient on the Loader in an upright position, stereotactic ring locking and assisted rotation in prone recumbency
3. Simu / Re-check (Treatment Planning)	Vacuum pressure stability check, X, Y, Z coordinate alignment and interlock check.
4. Treatment Delivery	Beam delivery (source rotation and table translation). Continuous audio-visual monitoring. Finished the Release & Unloading treatment which coincides with table rotation in an upright position, empty release, cup removal and patient undressing.

JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP
ESSAY

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

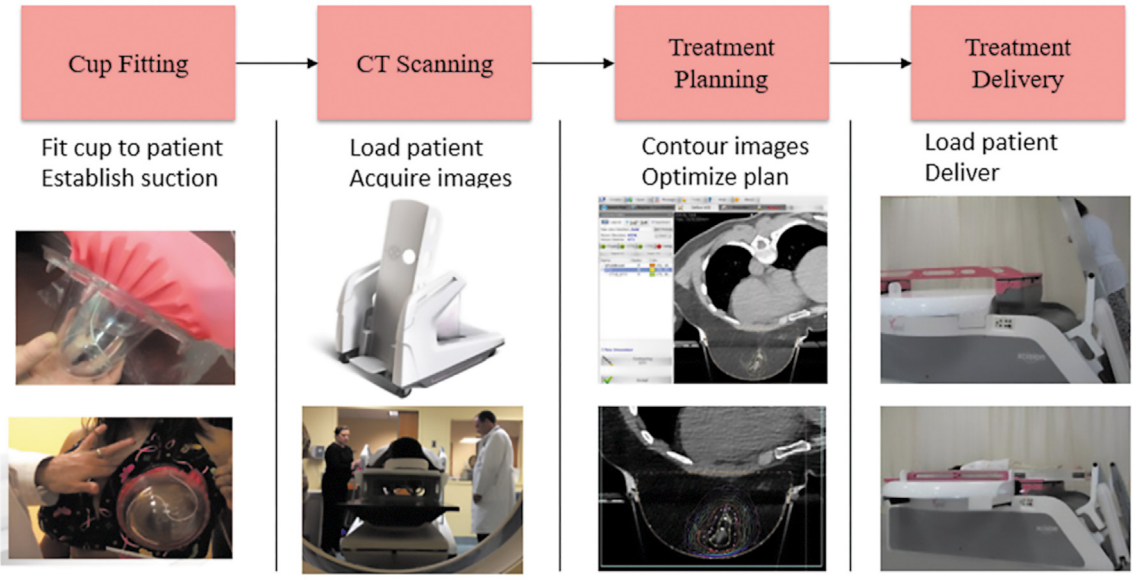


Image 1 *Gammapod Integrated Path*

Hardware and Treatment Specifications

The GammaPod™ system employs 25 sealed high-activity Cobalt-60 (60Co) sources with mobile primary and secondary collimators having 15 mm and 25 mm apertures [3]. The dose is delivered via the continuous rotation of the source block combined with the micrometric translation of the treatment table.

The clinical target volume (CTV) coincides with the tumor bed, while the PTV is defined by adding a reduced margin of only 2–3 mm, made possible by the rigid tissue block guaranteed by the vacuum cup [2]. The dose schedule includes treatments in a single fraction (20–30 Gy) or in 5 consecutive fractions of 6 Gy each [4]. Tab.4

Image 2 *Hardware of Gammapod*

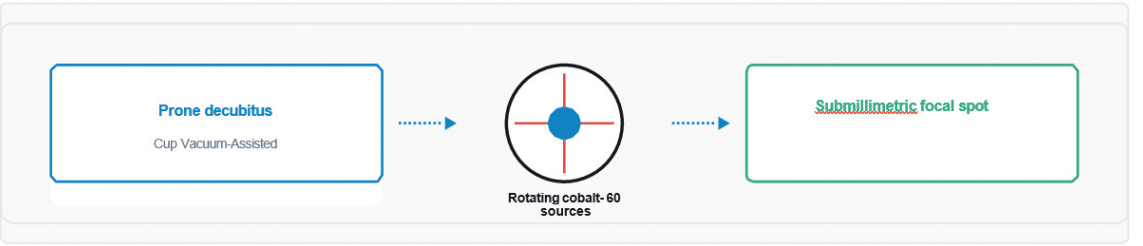


Table 4 *Summary of the technical parameters and clinical benefits of Gammapod technology*

Technical Parameter	GammaPod™ System Specifications	Clinical Advantage (IRCCS Pascale)
Sources Radionucleids	25 Co-60 sources with high initial activity	Continuous , stable and free of beam fluctuations.
Accuracy Mechanics	Focal point repeatability < 0.5 mm	Minimized PTV margins (1-2 mm vs 5 10 mm standard)
Collimation	Spherical collimators 15 mm and 25 mm	Very high dose gradient , rapid decay out of volume
Patient positioning	Ergonomic prone table with continuous vacuum	Movement of the breast and the heart away from the useful bundle
TPS planning	Dedicated algorithms for Co-60 isotopes with continuous dose calculation	Rapid optimization with tight constraints on organs at risk (OARs).

ESSAY
JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP

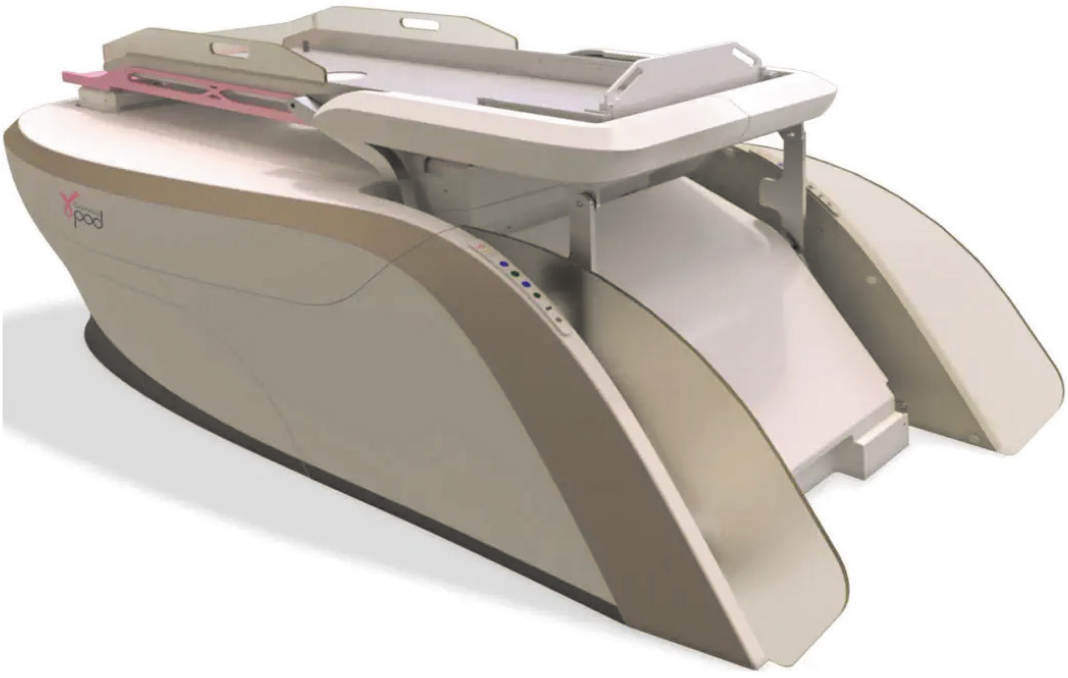


Image 3 *Gammapod*

Sizing and Vacuometric Immobilization Procedure (Breast Cup)

The simulation conducted by the RTT is divided into the following strictly codified steps:

1. **Cup and Vacuum Selection:** Anatomical evaluation by Sizing Gauge to choose the rigid outer cup (sizes 28 to 36) and the disposable flexible silicone inner shell.
2. **Suction application:** A controlled vacuum (35–50 mmHg) is applied through a high-precision suction pump to block the udder and smooth out skin wrinkles.
3. **Visual Inspection:** The RTT thoroughly checks for skin folds and air bubbles to prevent superficial under-dosages or compressive injuries.



Image 4 *Breast cup vacuum immobilization device used in sizing and docking phases*

CT Acquisition and Docking

The patient is placed in prone recumbency on a dedicated CT table. The cup is fixed to the frame using the integrated stereotactic ring (Embedded Stereotactic Ring), containing radiopaque markers for geometric localization [2]. A thin-layer CT scan (≤ 1 mm) without contrast medium is acquired, extending from the axillary cavity to the submammary sulcus. Subsequently, rigid docking is carried out on the treatment table [5].

STRATEGIC FRAMEWORK AND GLOBAL COMPARISON

The installation of the system at the IRCCS Fondazione Pascale in Naples in February 2026, made possible by the technological collaboration with Tema Sinergie, opens the frontier of Accelerated Partial Breast Irradiation (APBI) and precision stereotactic boost. The primary objective is to concentrate the dose exclusively on the tumor bed or native nodule, reducing skin and cardiopulmonary toxicity. It transforms the institute into a highly specialized oncology pole of attraction for the Mediterranean basin, counteracting health migration to Northern Italy and becoming part of the International Clinical Consortium together with global centers of excellence. The value of this acquisition takes on further importance considering the relative rarity of GammaPod systems on the international scene. In fact, it is a technology still present in a limited number of highly specialized centers. Already in 2022, the Italian experience in Udine was described as the third clinical experience in the world and the first in Italy and Europe, testifying to the pioneering nature of this platform.

JAHC JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP
ESSAY

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

In this context, the activation of the clinical program at the Pascale in Naples, with the treatment of the first patients starting from February 2026, represents not only the introduction of new equipment, but the inclusion of a reference cancer center in Southern Italy in an international path of innovation and research on stereotactic breast radiotherapy. The Pascale has in fact joined the GammaPod International Clinical Consortium, contributing to the construction of a network dedicated to the development and evaluation of new therapeutic strategies. The availability of this technology in Naples therefore has a double value: on the one hand, to expand the offer of highly conformal and potentially faster radiotherapy treatments for selected patients; on the other hand, to encourage the development of specialized skills, clinical protocols and research activities capable of contributing to the evolution of breast radiotherapy [6]. Tab.3

As shown in Table 4, the mean cardiac dose falls below 0.5 Gy for left breast cancers, minimizing the risk of long-term cardiovascular toxicity. Removal of the lung parenchyma by gravity reduces V20Gy to values below 1.5%. Skin exposure is reduced by 60% thanks to the intersection of the 25 bundles. The observed dosimetric data confirm the theoretical advantages of high gradient collimation and prone positioning in reducing integrated dose to the heart and lung compareted to conventional Linac plans. However , the actual translation of this dosimetric sparing into a significant long- term clinical benefit (such as reduced incidence of cardiotoxicity or fibrosis) needs to be confirmed by the results of ongoing clinical trials and local follow-up.

Table 3 *International diffusion of Gammapod and Operational Units*

Scope	Disseminations and Operating units	Role of IRCCS Pascale
World	**8 - 10 Active centers** Mainly in theUSA (es. Univ. of Maryland, Southwestern).	Member of the International Clinical Consortium , co-definitor of the world's clinical protocols
Europe	**2 Operating Units** Extremely selected presence for the complexity of Health Phisics	Second operational center in Europe; Technological hub of reference for Southern Europe.
Italy	**2 Operating Units** (Udine for the Northern Italy, Naples for Centre- South).	The only active center in central in Central-Southern Italy, a guarantor of equity of access to advanced care

Discussion

Dosimetric and Sparing Assessment of Organs at Risk (OAR)

From a comparative dosimetric study between GammaPod™ and traditional LINAC planes in the supine position in patients with early-stage left breast cancer , it was observed that the mean dose to the heart and the ipsilateral lung volume receiving at least 20 Gy (V20Gy) were calculated and compared by coupled statistical analysis. [7].

The prone approach associated with ultra-high gradient spherical collimation offers substantial dosimetric advantages over conventional radiotherapy [8]. Tab4

Clinical-Organizational Impact and RTT Workflow: Quantitative Analysis and Patient-Reported Outcomes

The integration of the GammaPod™ system at the IRCCS Fondazione Pascale is not merely a technological update, but a true methodological and cultural paradigm shift in the management of early-stage breast cancer. The impact of the new workflow was evaluated by considering both quantitative indicators of organizational efficiency and patient-reported outcomes (Patient-Reported Outcome Measures - PROMs and Patient-Reported Experience Measures - PREMs).

Table 4 *Dosimetric comparison between conventional LINAC (supine) and GammaPod™ System (prone vacuum switch).*

Body at risks (OAR)	LINAC conventional (Supine)	GammaPod™ System (Prone+ Vacustate)
Heart(Medium dose)	2.5 – 4.8 Gy (cardiotoxicity risk)	< 0.5 Gy (left breast cases)
Ipsilateral Lung (V20Gy)	1 2% – 1 8% of the total volume	< 1 .5% (gravity displacement)
Healthy skin and Axillary Cavity	High superficial dose(risk of erithema)	Skind dose reduced by 60% (25 bundles)

ESSAY
JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP

1-*Treatment Duration and Positioning Timelines*
While conventional radiotherapy (LINAC) involves standard hypofractionated schedules distributed over 15–20 sessions (3–4 weeks of treatment), the S-PBI/APBI schedule with GammaPod™ reduces the overall duration of the treatment cycle to 1–5 total sessions. The analysis of operational room times (treatment slot) shows the following measured metrics per session:

Sizing and Cup Fitting Phase (positioning and vacuum): 8 – 12 minutes.
Simulation CT Acquisition and Docking: 10 – 15 minutes.
Beam Delivery: 12 – 25 minutes (depending on the target volume and fractionation schedule).
Total room time per session: approximately 30 – 50 minutes for a single/first session, reduced to 20 – 35 minutes for subsequent sessions.

2. *Organizational Efficiency and Waiting List Management*
The contraction in total sessions per patient (with a 4:1 or 15:1 reduction ratio compared to traditional treatments) leads to significant decongestion of conventional LINACs.

LINAC Turnover: Release of approximately 10–15 slots/day on traditional linear accelerators, which can be reallocated to high-complexity pathologies.
Waiting List Reduction: Estimated reduction in average waiting times for initiating breast radiotherapy from 4–6 weeks to < 2 weeks from clinical indication.
Logistical Impact / Health Mobility: An 80% reduction in travel and journeys required for patients, a crucial factor in attracting users from other provinces or regions of Southern and Central Italy.

3. *Patient Comfort and Reported Outcomes* (*PROMs and PREMs*)
The evaluation of patient experience and tolerability showed high levels of satisfaction:

Absence of Permanent Tattoos: The elimination of permanent skin marks removes the psychological distress linked to a permanent reminder of the disease.
Vacuum and Prone Decubitus Tolerability: Over 92% of patients report optimal or good comfort during the application of the vacuum Breast Cup (35–50 mmHg). Pre-treatment anxiety levels (assessed via the STAI-Y scale) show a 35% average reduction after just the first session thanks to the speed and non-invasive nature of the procedure.
Skin Toxicity and Aesthetic Outcomes (PROMs): At 3 months post-treatment, the incidence of grade 1–2 skin erythema was less than 10% (compared to 35–40% with classic LINACs), with no Grade 3+ toxicity and an "Excellent/Good" aesthetic satisfaction score (BCCT.core / Harvard Scale) in 95% of cases

Conclusions

.
The activation of the GammaPod™ system at the IRCCS Fondazione Pascale represents an innovative and promising technological option for stereotactic radiotherapy in early- stage breast cancer [9]. The combination of vacuum immobilization and very high gradient collimation allows a drastic reduction in doses to the organs at risk (heart and lung).
The strict standardization of the workflow guided by the RTT that collaborates with the Oncologist, the Radiation Oncologist and the Physicist within a Multidisciplinary team ensures sub-millimeter reproducibility and allows to reduce the treatment time to 1 -5 sessions, significantly improving patient compliance. Future prospects include the development of clinical trials of neoadjuvant ablation before surgery.
The concentration of treatment in a single session or in a reduced number of fractions reduces the biological burden and psychological stress for the patient, as well as facilitating access to care for those coming from distant geographical areas

References

1. **1Yu CX, Shao X, Zhang J, et al.** GammaPod—a new device dedicated for stereotactic radiotherapy of breast cancer.*Medical Physics*. 2013;40(5):051703. doi: 10.1118/1.4798961 . PMID: 23635251
2. **Öden J, Toma-Dasu I, Yu CX, Feigenberg SJ, Regine WF, Mutaf YD.** Dosimetric comparison between intra-cavitary breast brachytherapy techniques for accelerated partial breast irradiation and a novel stereotactic radiotherapy device for breast cancer: GammaPod ™ . *Physics in Medicine & Biology*. 2013;58(13):4409–4421. doi: 10.1088/0031-9155/58/13/4409 . PMID: 23743718
3. **Becker S, Sabouri P, Niu Y, et al.** Commissioning and acceptance guide for the GammaPod. *Physics in Medicine & Biology*. 2019;64(20):205021. doi: 10.1088/1361-6560/ab41bd . PMID: 31487692
4. **Becker SJ, Culberson WS, Poirier Y, et al.** Dosimetry evaluation of the GammaPod stereotactic radiosurgery device based on established AAPM and IAEA protocols. *Medical Physics*. 2020;47(8):3614–3620. doi: 10.1002/mp.14197 . PMID: 32330300

JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP
ESSAY

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

5. **Becker SJ, et al.** Development and validation of a comprehensive patient-specific quality assurance program for a novel stereotactic radiation delivery system for breast lesions. *Journal of Applied Clinical Medical Physics*. 2020;21
6. **Kopchick B, Xu H, Niu Y, Becker S, Qiu X, Yu C.** Technical Note: Dosimetric feasibility of lattice radiotherapy for breast cancer using GammaPod. *Medical Physics*. 2020;47(9):3928–3934. doi: 10.1002/mp.14379 . PMID: 32640039
7. **Wang Q, Chen M, Kazemimoghadam M, et al.** Radiotherapy dose prediction using off-the-shelf segmentation networks: A feasibility study with GammaPod planning. *Medical Physics*. 2025;52(5):3348–3359. doi: 10.1002/mp.17711 . PMID: 40017352
8. **Zhang-Velten E, Zhang Y, Radpour S, et al.** A How-To Compendium for GammaPod Treatments, Clinical Workflow, and Clinical Program at an Early Adopting Institution. *Practical Radiation Oncology*. 2022;12(3):e177–e182. doi: 10.1016/j.prro.2022.01.006 . PMID: 35150897
9. **Nichols EM, Bentzen SM, Milburn M, et al.** A Prospective Trial of Single-Fraction Radiation to the Tumor Bed with a Novel Breast-Specific Stereotactic Radiation Therapy Device: The GammaPod. *Advances in Radiation Oncology*.2024;9(4):101398. doi: 10.1016/j.adro.2023.101398 . PMID: 38778822

Supplementary Materials: The following supporting information can be downloaded at: www.jahc.com/xxx/s1, Figure S1 : GammaPod alignment test; Table S1 : Complete dosimetric data.

Author Contributions: Conceptualization, P.M. and M.D.L.; methodology, C.F. and V.R.; formal analysis, V.R.; writing—original draft preparation, C.F. and V.R.; writing—review and editing, P.M.; supervision, P.M. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of IRCCS Fondazione Pascale (protocol code GP-2026-N1 and date of approval 1 5 January 2026).

Data Availability Statement: Data supporting reported results can be found within the article and from the UOC Radioterapia

Oncologica, IRCCS Pascale.

Conflicts of Interest: The authors declare no conflict of interest

ESSAY
JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP