Criticità del sistema per piani di trattamento nelle moderne procedure radioterapiche

Sicurezza in Radioterapia

Davide Raspanti, Ing., *Senior Product Specialist*

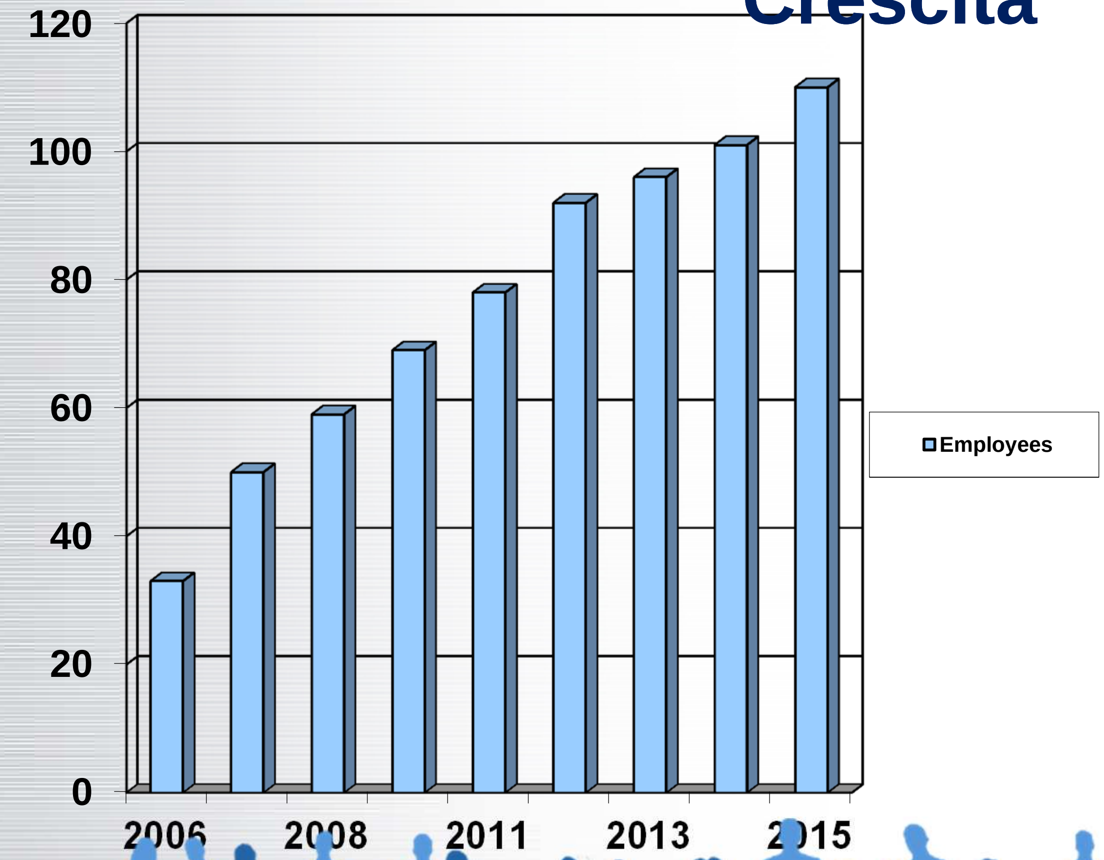
TEMA SINERGIE

Introduzione

- **Dal 1985 TEMA SINERGIE si occupa di progettazione, produzione, vendita ed assistenza di sistemi schermati e strumentazione di misura per il corretto utilizzo in sicurezza delle sostanze radioattive, principalmente per applicazioni PET / Medicina Nucleare**

TEMA SINERGIE: profilo

Crescita



116 dipendenti

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Introduzione

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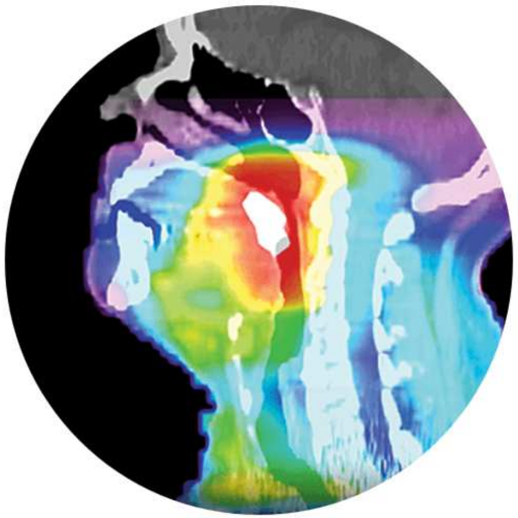
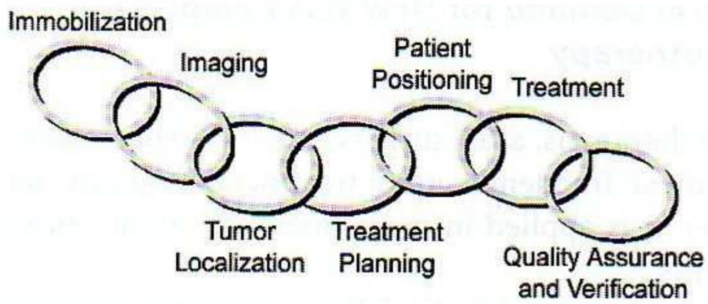
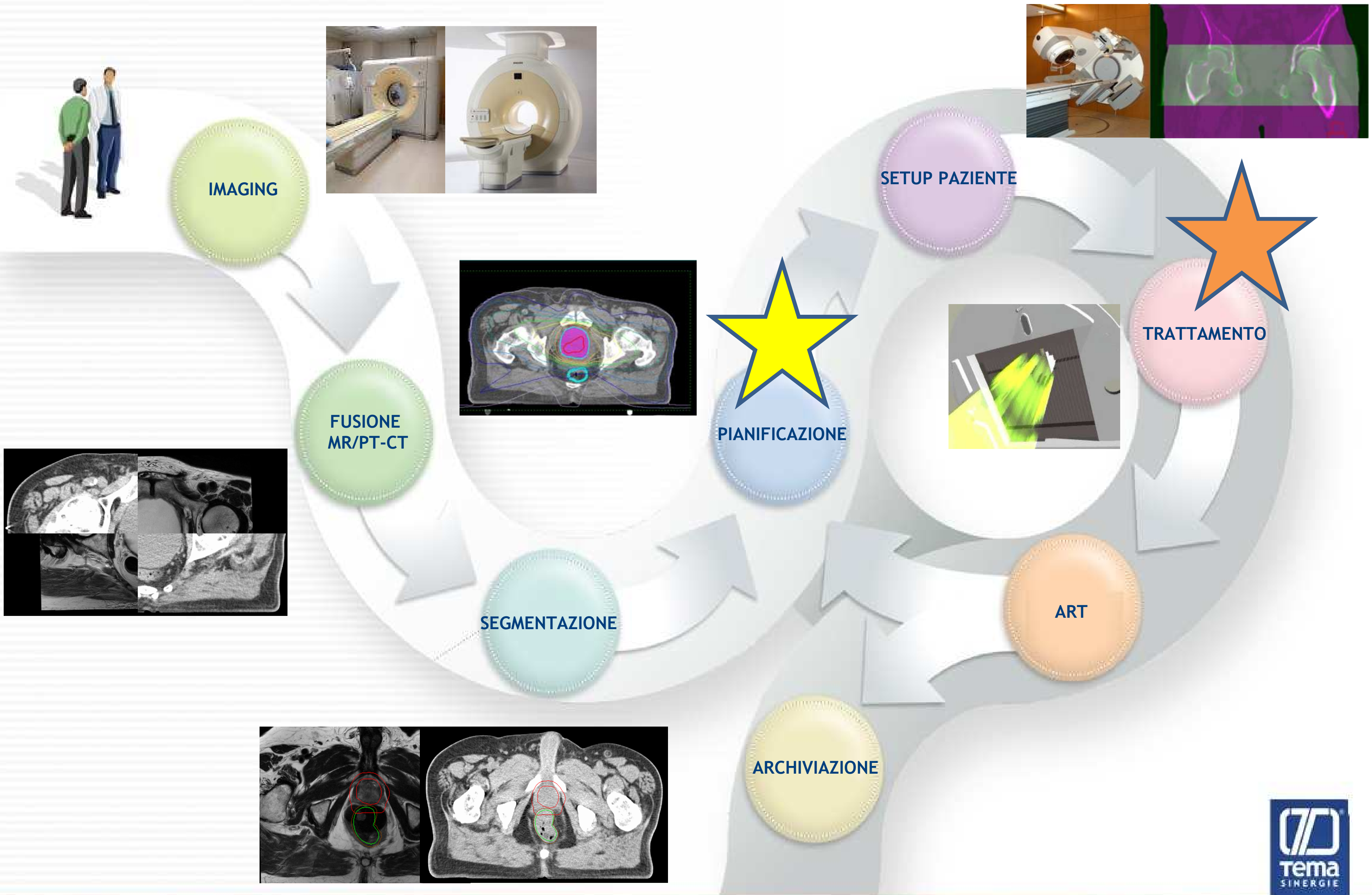


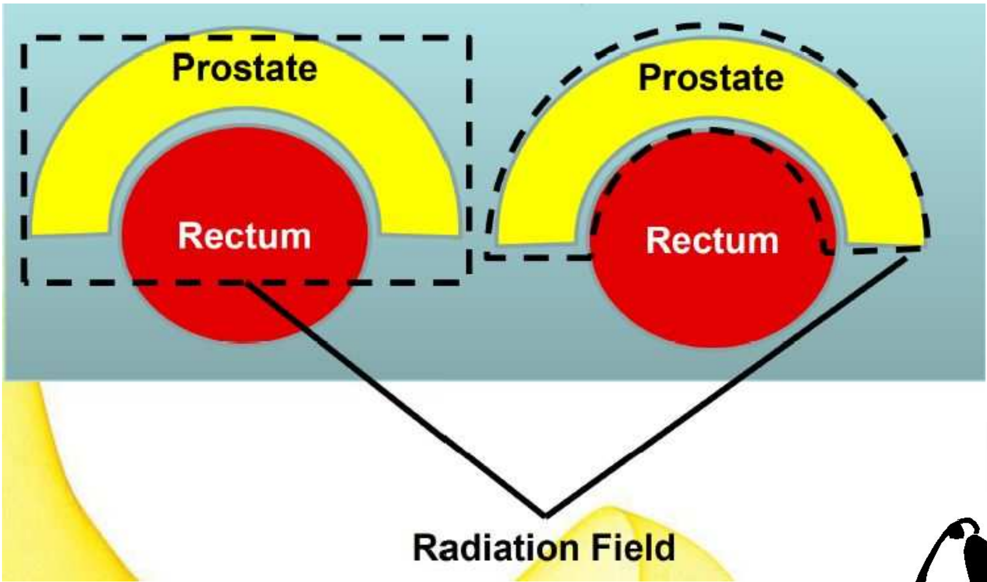


Il flusso di lavoro della moderna Radioterapia: CRITICITA’



CRITICITA' NELLA PIANIFICAZIONE DEL TRATTAMENTO: COMPLESSITA'

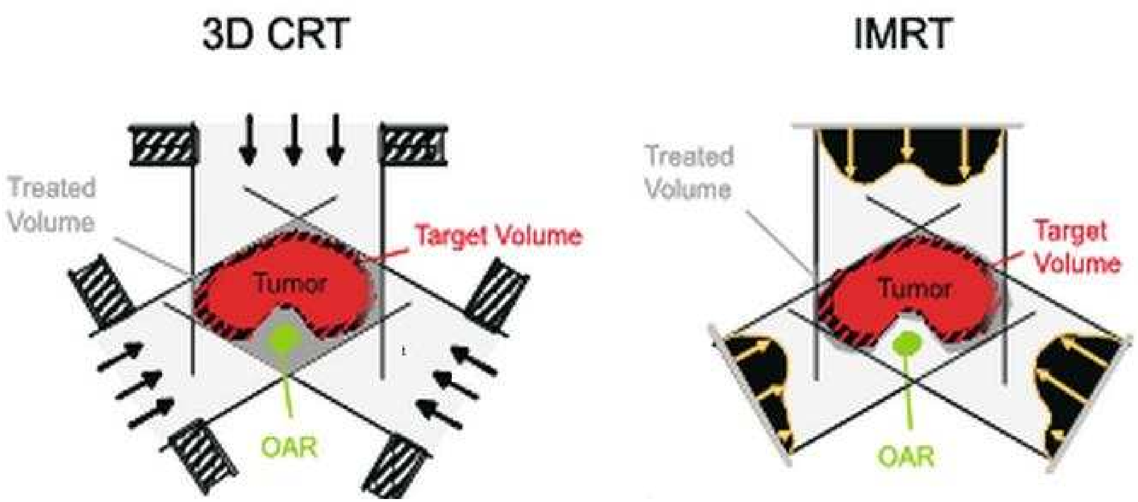
- Fin dall'introduzione dei primi acceleratori lineari (LINAC) negli anni '50, lo scopo della pianificazione del trattamento radioterapico è stato quello di **conformare al meglio la dose alla forma ed alle dimensioni del tumore**

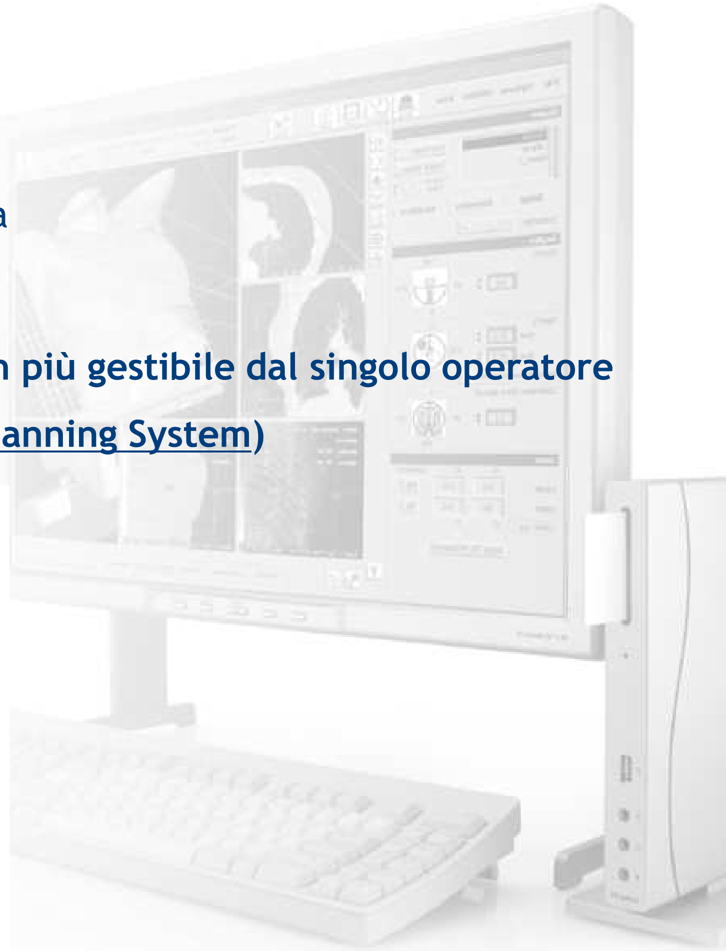


- …ma come possiamo assicurare che ciò avvenga
  - tenendo conto del fatto che l'intensità del fascio è uniforme?
  - risparmiando al meglio gli organi a rischio (OAR) con una rapida caduta di dose? Infatti, ≈30% dei tumori ha forma concava!
  - mantenendo la possibilità di effettuare dose escalation?

IMRT (Intensity Modulated RadioTherapy): benefici ma anche complessità crescente

- **L'IMRT introduce indiscussi vantaggi…**
  - riducendo la dose agli organi a rischio
  - incrementando la conformità al tumore della dose prescritta
  - favorendo la riuscita clinica del trattamento
- **…ma comporta un livello di complessità della pianificazione non più gestibile dal singolo operatore in modo autonomo senza strumenti dedicati (TPS, Treatment Planning System)**





IMRT: dalla pianificazione diretta alla pianificazione inversa

Forward planning

(dalla definizione dei campi di trattamento al calcolo della dose)

- Geometria, prescrizione della dose e parametri di modulazione
- Calcolo della dose
- Erogazione della dose con intensità uniforme dei fasci

Inverse planning

(dalla distribuzione di dose alla definizione dei campi di trattamento)

- **Erogazione della dose con intensità non uniforme dei fasci**
- **Ottimizzazione mediante algoritmi computerizzati**
- **Generazione delle sequenze di segmenti con i relativi beamlet**
- **Goal clinici (funzioni obiettivo)**

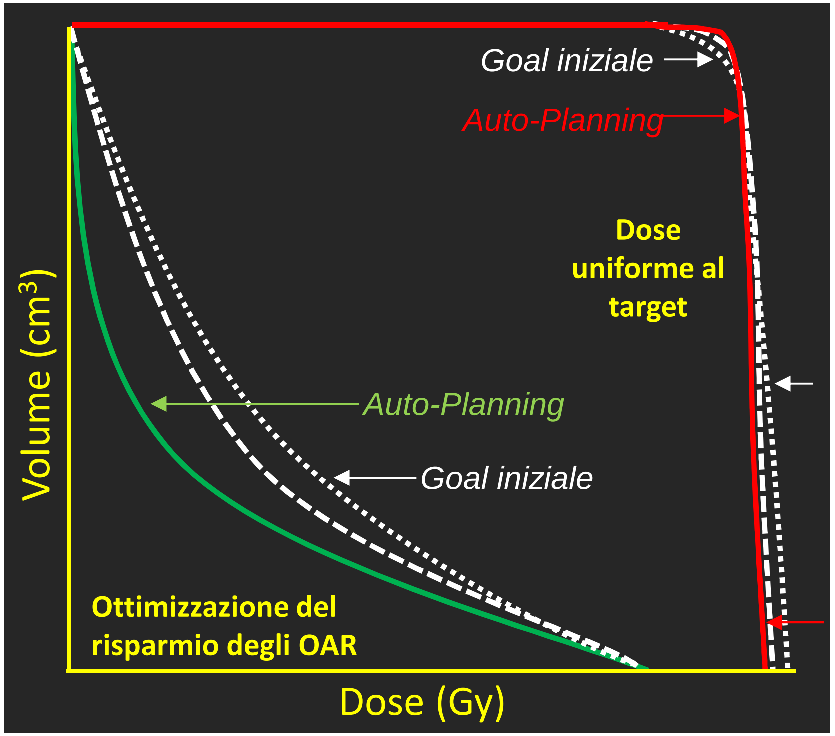
IMRT: dalla Radioterapia 1.0…

- Il processo di Inverse Planning si rivela spesso complesso ed inefficiente
  - numero molto elevato di operazioni e passaggi, la maggior parte ripetitivi
  - gli algoritmi di ottimizzazione non sono totalmente automatici ma necessitano di un’interazione continua e laboriosa con utenti esperti
  - i risultati sono spesso sub-ottimali a causa del limitato tempo a disposizione, routine e complessità
  - i piani risultanti possono anche essere molto diversi fra loro, in termini di distribuzione di dose ed efficienza dell’erogazione, al variare dell’operatore

Preplanning (contouring) →  → Review ed approvazione

…alla Radioterapia 2.0 con Pinnacle Auto-Planning: l'ottimizzatore dell'ottimizzatore

- Pinnacle Auto-Planning ottiene questi risultati…



- …"comportandosi" come un utente esperto senza limite di tempo…

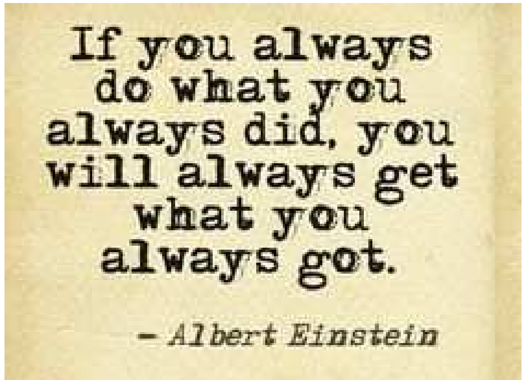
In output, piani clinici ed erogabili

I protocolli tradizionali (RTOG, QUANTEC, ecc.) diventano obsoleti?

Pinnacle Auto-Planning: un approccio innovativo

Optimization Library-based

- Interazione minima dell'operatore in fase di planning
- Possibilità di conformarsi alle singole specificità cliniche ma con ridefinizione della libreria



Optimization pareto-based

- Possibilità di analisi, correzione e scelta del "miglior" piano di trattamento mediante interfaccia grafica interattiva

Optimization algorithm-based

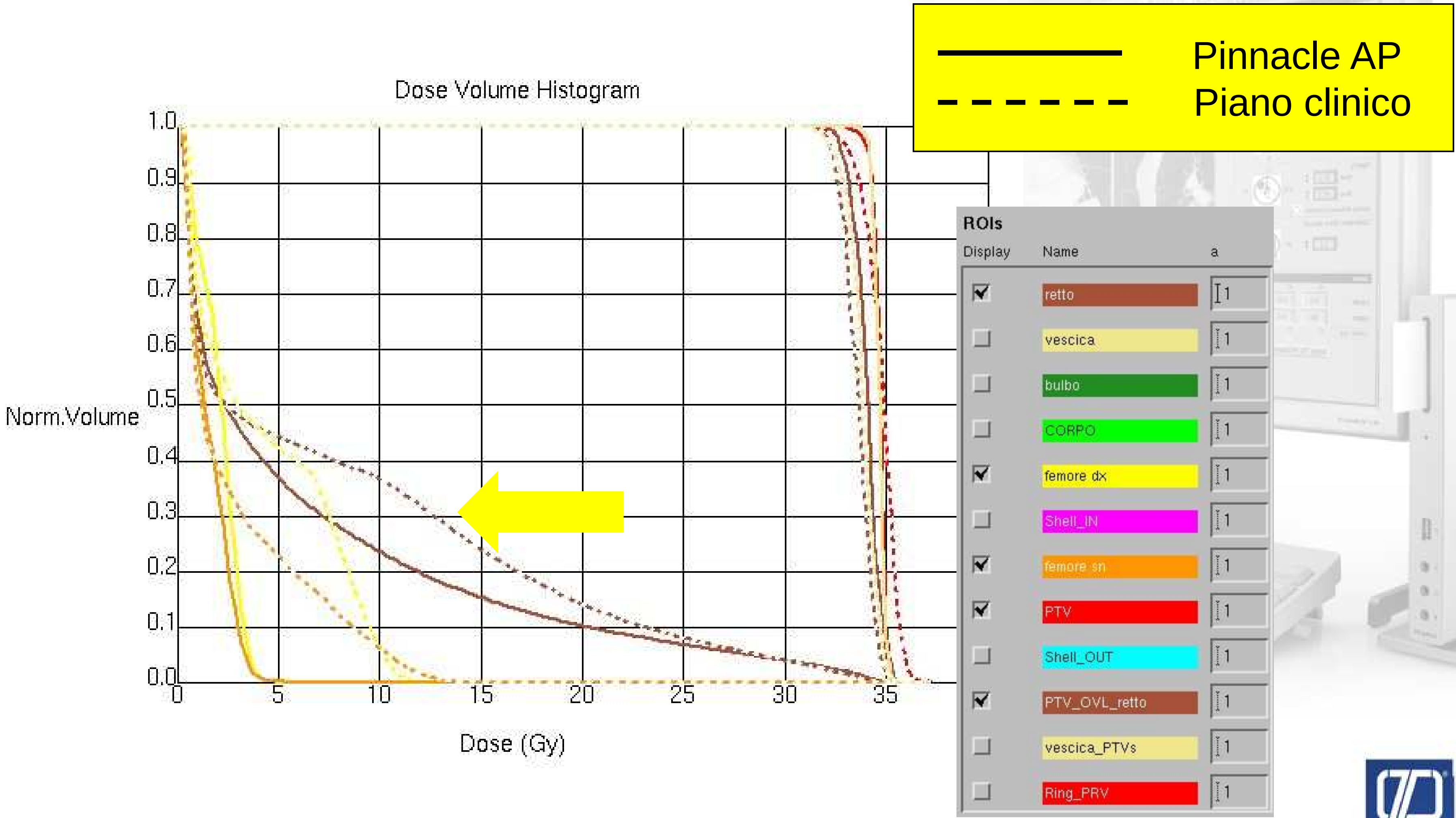
- Pronto per l'uso ai massimi livelli di qualità, efficienza e consistenza
- Interazione minima dell'operatore in fase di planning
- Piena adattabilità a casi clinici specifici

Pinnacle Auto-Planning: confronto con la pratica clinica

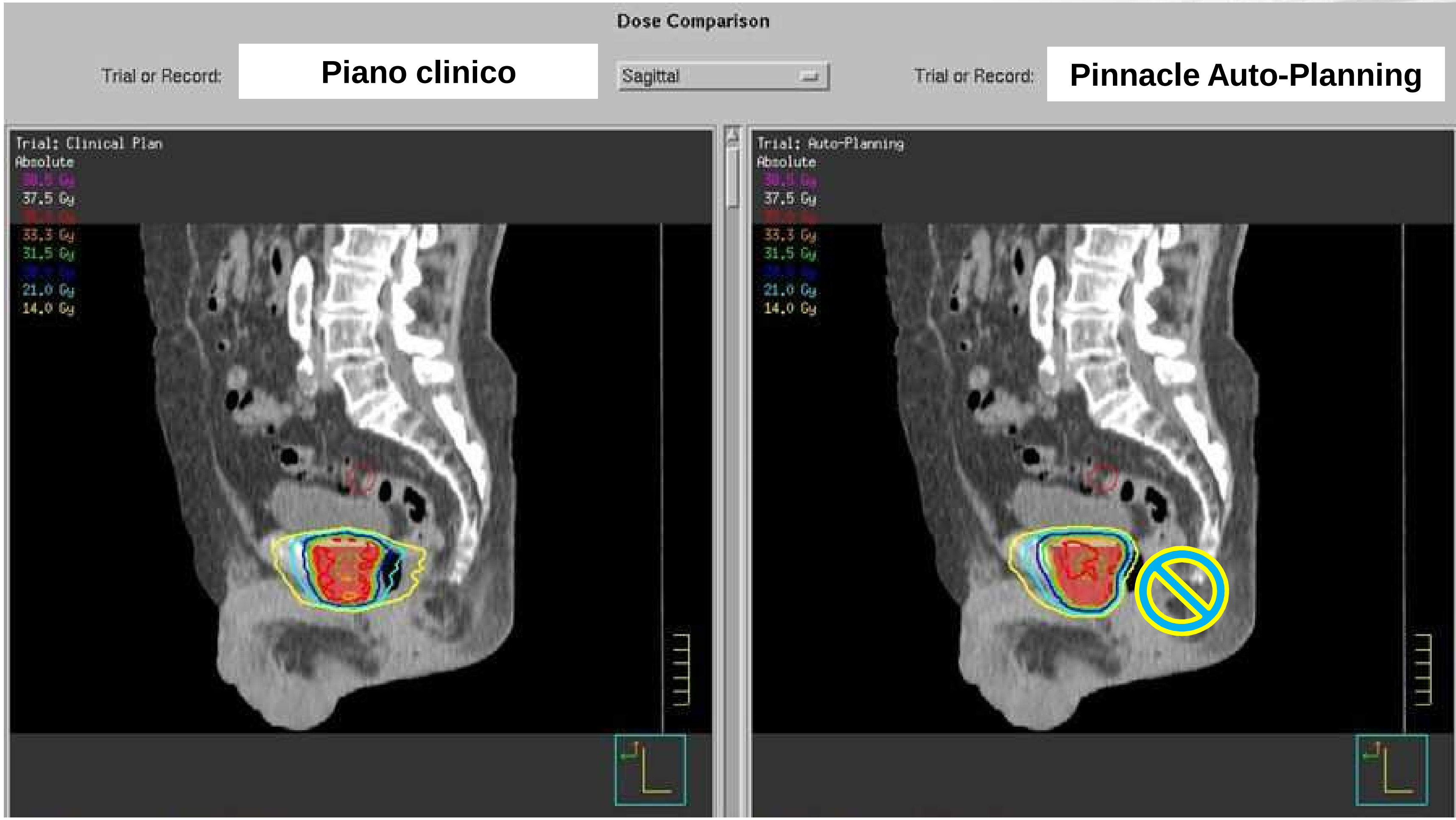
- Caso 1: distribuzione di dose

Pinnacle Auto-Planning: confronto con la pratica clinica

- Caso 1: DVH (Dose Volume Histogram)

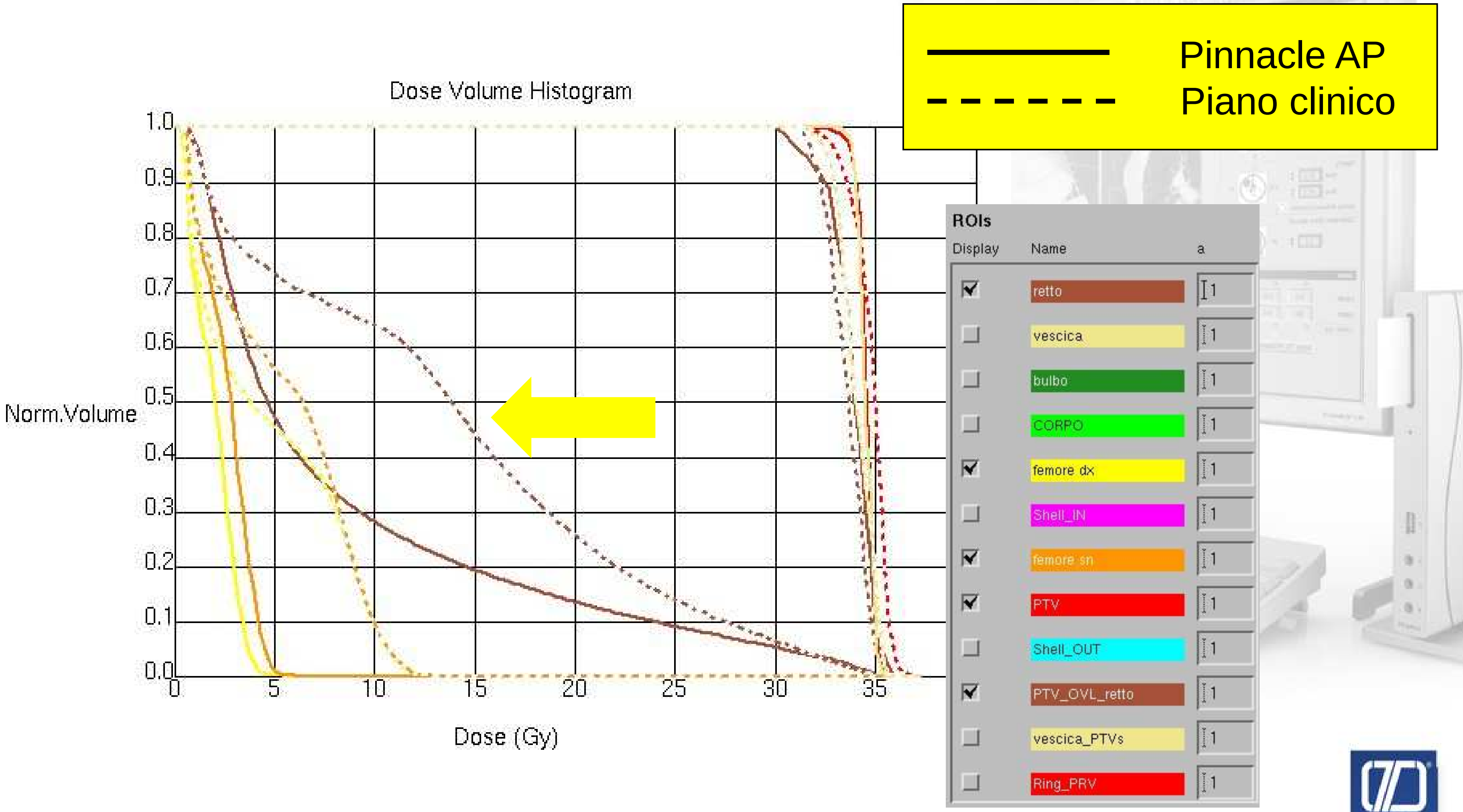


- Caso 2: distribuzione di dose



Pinnacle Auto-Planning: confronto con la pratica clinica

- Caso 2: DVH (Dose Volume Histogram)

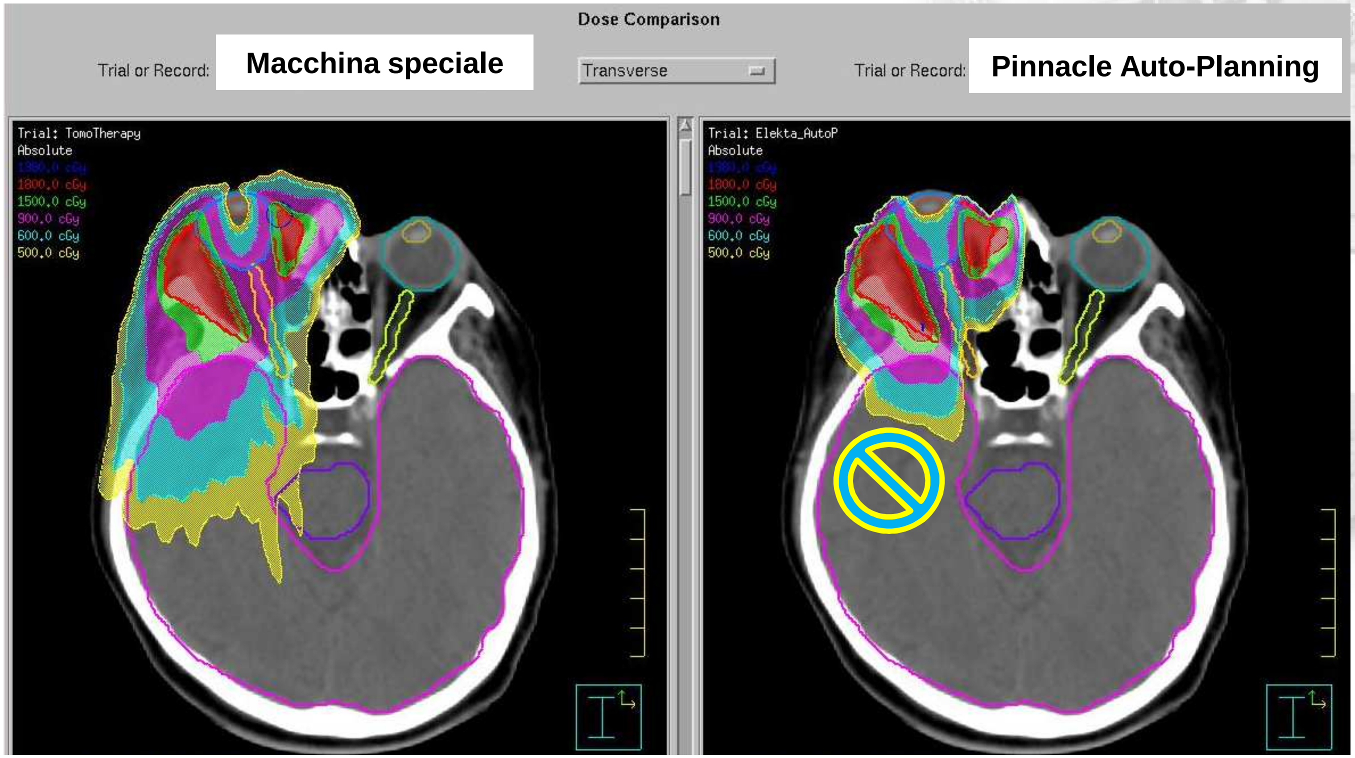


Pinnacle Auto-Planning: la macchina radiante come «stampante»

- Ai fini della garanzia di alta qualità del trattamento radiante è **necessario** che l'acceleratore lineare (Linac o macchina «speciale» quale CyberKnife, TomoTherapy, Protonterapia) funzioni correttamente e garantisca certe prestazioni/caratteristiche, ma ciò **non è condizione sufficiente:** se il progetto/planning non è di buona qualità, anche disponendo di un acceleratore in condizioni ottimali e con le migliori e più costose caratteristiche del mondo, si otterrà comunque un risultato/trattamento non di buona qualità

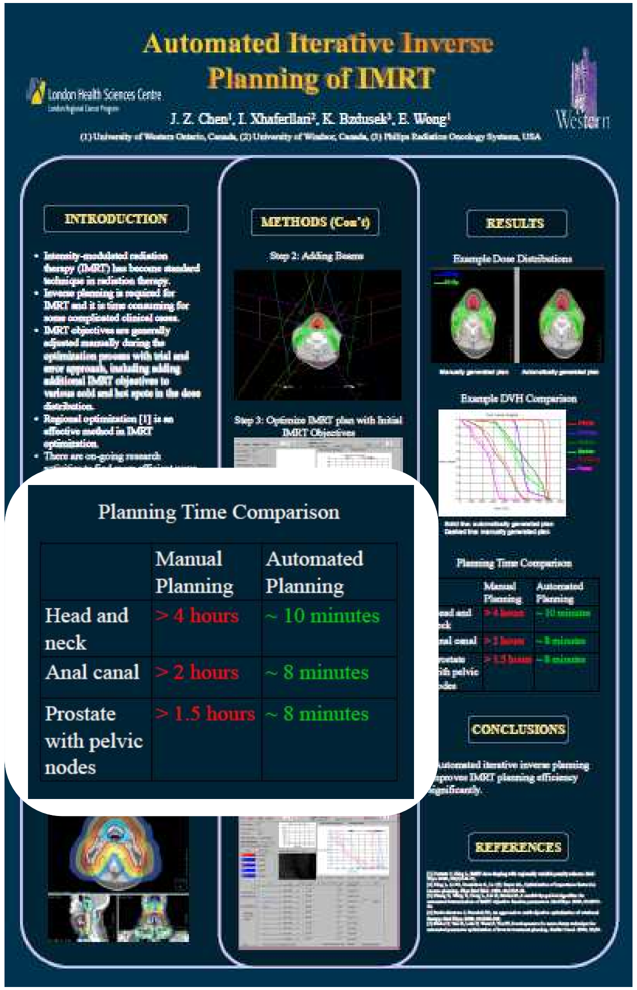
Orbita destra:

18 Gy in 3 Fr

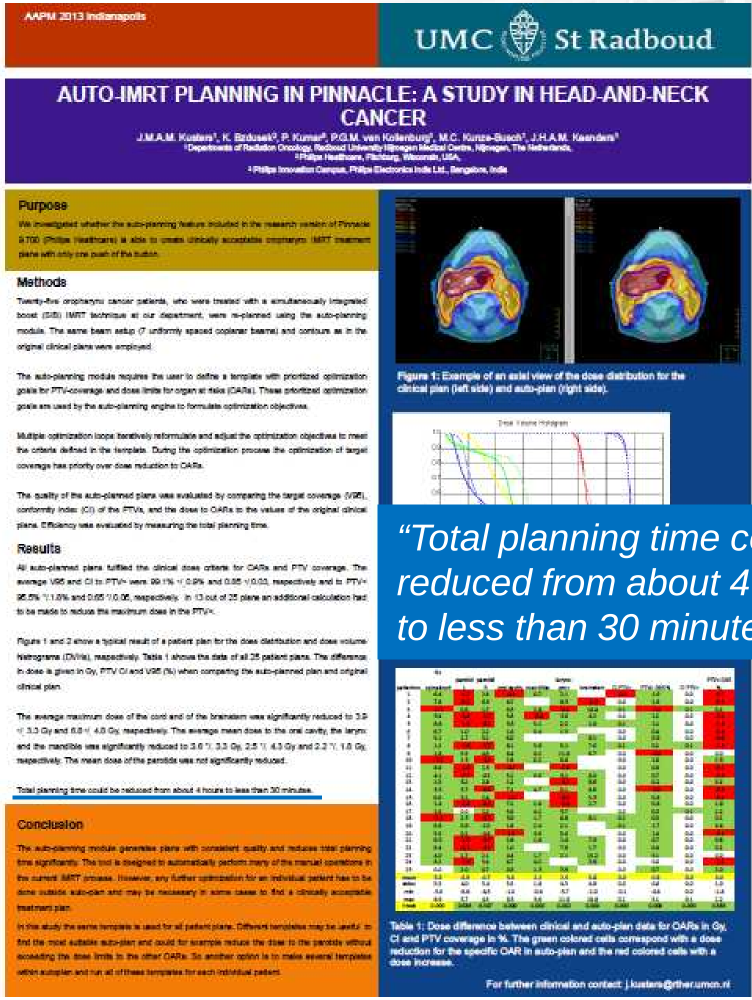


Pinnacle Auto-Planning: pubblicazioni recenti

- Riduzione del tempo complessivo di pianificazione



	Manual Planning	Automated Planning
Head and neck	> 4 hours	~ 10 minutes
Anal canal	> 2 hours	~ 8 minutes
Prostate with pelvic nodes	> 1.5 hours	~ 8 minutes



"Total planning time could be reduced from about 4 hours to less than 30 minutes"

Tema Sinergie

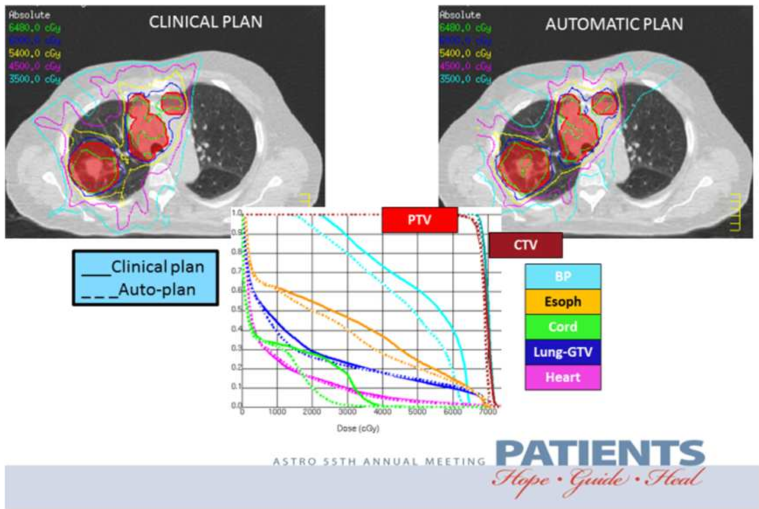
Pinnacle Auto-Planning: pubblicazioni recenti

- Qualità dei risultati, pari o superiore a quelli ottenuti dalla pratica clinica

"Automatic plans were able to meet all clinical goals achieved by physicists planning"

Automatic IMRT Treatment Planning using Templates with Automated Optimization Tuning Methods - *Schuster et al*

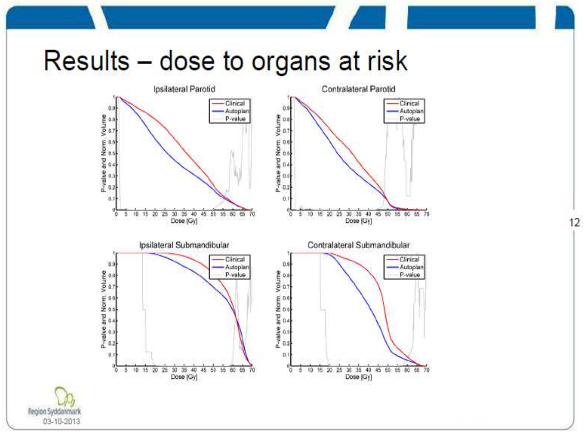
- Joint publication between VCU & Philips



"Physicians chose algorithmic auto-plans 75% of the time"

Automatic Planning of Head and Neck Treatment Plans - a Way to Optimize the Plan Quality and Reduce Workload – *Hazell et al.*

- Joint publication between Odense & Philips
- Retrospective planning study on 26 patients with Oropharyngeal carcinoma



Chasing Lung

CANCER THERAPY & RESEARCH CENTER
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Dosimetric Comparison Between Pinnacle³ Auto-Planning and Manual Planning for Lung SBRT Treatments

Aaron Bishop, B.S., Ying Li, M.D., Ph.D., N. Papanikolaou, Ph.D., Neil Kirby, Ph.D., D Baacke, B.S., Alonso Gutierrez, Ph.D., M.B.A.
Department of Radiation Oncology, University of Texas Health Science Center San Antonio, San Antonio, TX

Introduction

Stereotactic body radiation therapy (SBRT) has become an effective treatment option for early stage and small metastatic lung tumors. Due to plan complexity with SBRT, traditional, inverse optimized IMRT planning may be time consuming and the quality of plans is likely to vary with the skill and experience of the planner. Auto-Planning, a new functionality developed by Pinnacle³, has been made commercially available with Version 9.10. Auto-Planning is a tool that automates and facilitates inverse optimization of treatment plans. Benefits of Auto-Planning are based on planning efficiency improvements and standardization of plan quality. The aim of this study is to dosimetrically compare the treatment plan quality of Auto-Planning against previously approved clinical plans.

Methods and Materials

- Twenty (n=20) lung SBRT patients previously treated using a non-coplanar, 6 MV fix-field IMRT technique with a 120 HDMLC Novalis Tx were replanned in Pinnacle³ (v9.10) with Auto-Planning.
- Patient plans were normalized to 5000 cGy in 5 fractions such that at least 98% of the PTV received 100% of the prescription dose, and the same beam geometries were used for Auto-Planning as the clinical plan.
- Metrics used for comparison were the dose fall-off ($R_x = V_{x\%}/V_{ptv}$) at the 70%, 50%, and 30% isodose lines, conformation number (CN), and homogeneity index ($HI = D_{0.2cc} / D_{98\%}$).
- Statistical differences were evaluated using a paired sample Wilcoxon signed rank test with significance level of 0.05.

Results

- For the dose fall-off of parameters, a mean percentage increase of 6.5%, 6.1% and 0.2% was found for the R_{70}, R_{50} and R_{30}, respectively, using Auto-Planning—however no statistically significant difference was noted.
- The CN showed a mean percentage difference of 1.7% (p<.0.05) decrease for Auto-Planning.
- The HI showed a mean percentage difference of 3.9% (p<0.05) improvement for Auto-Planning
- Auto-Planning did show an increase of 4.6% (p<0.05)in total monitor units but a 17.7% (p<0.05) decrease in the total number of control points.

Conclusion

Auto-Planning appears to generate SBRT treatment plans for lung lesions of similar treatment plan quality to the manually optimized, clinical plans. No statistically significant differences were noted for the dose fall-off parameters. Since it provided comparable plans, it can be used as a starting point to standardize plan quality and can be further improved manual optimization. With further experience, the Auto-Planning templet can be refined to produce better treatment plans.

Figure 1: (*left*) Cumulative, normalized dose volume histogram (DVH) for a sample lung SBRT patient using both manual and Auto-Planning techniques. (*right*) 3D rendering of the patient and beam geometry for a sample patient.

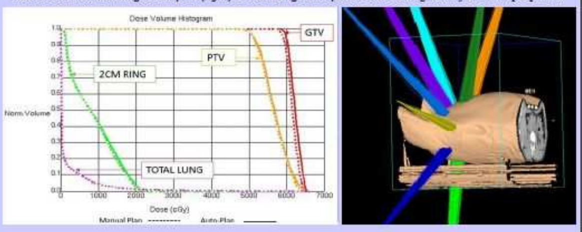

Figure 2: Axial simulation CT slice of a sample lung SBRT patient. (*left*) Dose distribution for manual treatment planning (*right*) Dose distribution for the Auto-Planning.

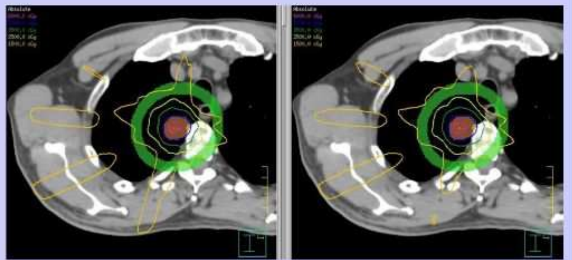

Table 1: Table shows the mean PTV parameter for conformity, dose fall off, dose heterogeneity, and total treatment plan Mus for all patients using Auto-Planning and manual planning.

	Manual Plan				Auto-Plan			
	Mean	Std	Min	Max	Mean	Std	Min	Max
HI	1.41	0.08	1.29	1.58	1.32	0.07	1.15	1.41
CN	0.92	0.04	0.84	0.97	0.90	0.03	0.83	0.94
R70	2.48	0.35	1.99	3.21	2.51	0.36	1.89	3.11
R50	4.64	0.76	3.61	5.92	4.67	0.83	3.58	6.14
R30	16.86	6.35	10.33	32.21	17.66	6.05	11.37	30.19
MU	2619	327	2021	3084	2731	447	1801	3605

AAMD 2016

Tema SINERGIE

Pinnacle Auto-Planning: pubblicazioni recenti

- Applicazione trasversale: Lung, Brain, Abdomen, Head and Neck, Prostate

Auto-Planning: A Dosimetric comparison of Phillips Pinnacle Auto-planning tool for Lung, Brain, Abdomen, Head and Neck and Prostate treatment sites.

Hasti Hesami, Amalia Flores, Sanya Makahani, Ancy Mathew, Elizabeth Medrano, Hirra Siddiqui, Jordan Sutton CMD, Peter Balter PhD.
University of Texas MD Anderson School of Health Professions- Houston, TX

THE UNIVERSITY OF TEXAS MD Anderson Cancer Center

Introduction

Treatment planning in radiation oncology is one of the most critical components in the field of radiation treatment. Medical Dosimetrists work with different treatment planning tools such as 2D, 3D, IMRT, and VMAT to acquire desired dose results to the target area. The most current tool is Auto-planning. It is designed to create a clinically acceptable plan by providing the plan optimization parameters and in real time, create and adjust the objectives to the Treatment Planning System. The purpose of this study is to investigate whether the Auto-planning tool can create a comparable plan to an already approved clinical VMAT plan.

Methods

Thirty patients, six from each of the following five treatment sites: Prostate, Head and Neck, Abdomen, Brain and Lung were optimized once and with the same parameters as the approved plan. The same target volumes that were defined by the physician on the already approved plan were used. Target goals and Organs at Risk constraints were inputted into the Auto-planning tool based off physician treatment "planning orders" as utilized by MD Anderson Cancer Center radiation oncologists.

Results

The following tables and figures compare the differences for Organs at Risk (OARs), Percent Coverage, and Monitor Units between approved plans and Auto-Plan .

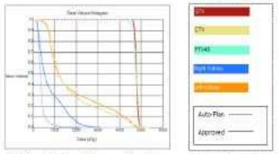

Fig.1 Dose Volume Histogram for abdomen case showing better kidney sparing by Auto-Plan as opposed to the Approved plan

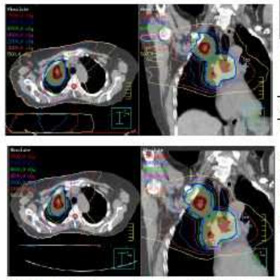

Fig. 2 Comparison of coverage for approved VMAT plan(top right and left) with PTV at 95 % and Auto-Plan (bottom right and left) with 85% in axial and coronal views.

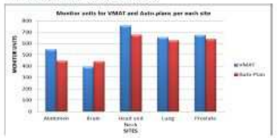

Fig. 3. Comparison of monitor units between approved plans and Auto-plans .

Critical Structures	Approved	Auto-Plan	%Difference
Rectum	V80=1.1%	V80=0.4%	63.6%
	V70=9.3%	V70=9.1%	2.2%
	V60=14.1%	V60=14.3%	1.4%
	V40=22.8%	V40=23.4%	2.6%
	V30=30.9%	V30=33.3%	7.2%
Femoral Heads	V50=0%	V50=0%	0%
	V45=0%	V45=0%	0%
Bladder	V70=5.2%	V70=5.1%	1.9%
PTV	98.7%	97.2%	1.5%

Table 1.Average OAR and Target coverage for Prostate treatment

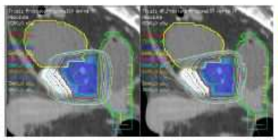

Fig. 5 No noticeable difference is seen between isodose lines of two trials

Critical Structures	Approved	Auto-Plan	%Difference
Brainstem	V30 = 20%	V30 = 26%	26%
	V55 = 0.3cc	V55 = 0.2cc	-40%
	V60 = 0cc	V60 = 0.03cc	200%
Brain	V30 = 38%	V30 = 41%	7.6%
Chiasm	Max: 3624cGy	Max: 3742cGy	2.7%
Lt Cochlea	Max: 1439cGy	Max: 1403cGy	-2.5%
	Mean: 996cGy	Mean: 1140cGy	13.5%
Rt Cochlea	Max: 457cGy	Max: 523cGy	13.5%
	Mean: 376cGy	Mean: 400cGy	6.2%
Lt Lens	Max: 359cGy	Max: 299cGy	-10.8%
Rt Lens	Max: 357cGy	Max: 271cGy	-27.4%
Lt Optic Nerve	Max: 3266cGy	Max: 2634cGy	-21.4%
Rt Optic Nerve	Max: 2847cGy	Max: 2052cGy	-32.5%
Pituitary	Mean: 2267cGy	Mean: 1776cGy	-24.3%
Rt Eye	Max: 1290cGy	Max: 898cGy	-35.8%
	Mean: 551cGy	Mean: 394cGy	-33.2%
Lt Eye	Max: 1645cGy	Max: 927cGy	-55.8%
	Mean: 533cGy	Mean: 445cGy	-18%
PTV	100%	98%	-1.6%
Boost PTV	97.5%	96%	-2%

Table 2 Average OAR and Target coverage for brain treatment site.

Conclusions

Auto-planning tool produces a clinically treatable plan in most cases, whether the plan is complex or not, by minimally providing a good plan up-front. The treatment planner could create an even more optimal plan, if needed. The auto-plans that were created were not the finishing point. They could have been optimized further to determine whether Organs at Risk are truly as low as reasonably achievable. In general, clinically acceptable and treatable plans could be created regardless of a treatment planner's skill.

References

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Tema SINERGIE

Pinnacle Auto-Planning: pubblicazioni recenti

- Pinnacle Auto-Planning come benchmark

Krayenbuehl et al. Radiation Oncology (2015) 10:226
DOI 10.1186/s13014-015-0533-2

RADIATION ONCOLOGY

RESEARCH Open Access

Evaluation of an automated knowledge based treatment planning system for head and neck

Jerome Krayenbuehl[1*], Ian Norton[2], Gabriela Studer[1] and Matthias Guckenberger[1]

Abstract

Background: This study evaluated an automated inverse treatment planning algorithm, Pinnacle Auto-Planning (AP), and compared automatically generated plans with historical plans in a large cohort of head and neck cancer patients.

Methods: Fifty consecutive patients treated with volumetric modulated arc therapy (Eclipse, Varian Medical System, Palo Alto, CA) for head and neck were re-planned with AP version 9.10. Only one single cycle of plan optimization using one single template was allowed for AP. The dose to the planning target volumes (PTV's; 3–4 dose levels), the organs at risk (OAR's) and the effective working time for planning was evaluated. Additionally, two experienced radiation oncologists blind-reviewed and ranked 10 plans.

Results: Dose coverage and dose homogeneity of the PTV were significantly improved with AP, however manually optimized plans showed significantly improved dose conformity. The mean dose to the parotid glands, oral mucosa, swallowing muscles, dorsal neck tissue and maximal dose to the spinal cord were significantly reduced with AP. In 64 % of the plans, the mean dose to any OAR (spinal cord excluded) was reduced by >20 % with AP in comparison to the manually optimized plans. In 12 % of the plans, the manually optimized plans showed reduced doses by >20 % in at least one OAR. The experienced radiation oncologists preferred the AP plan and the clinical plan in 80 and 20 % of the cases, respectively. The average effective working time was 3.8 min ± 1.1 min in comparison to 48.5 min ± 6.0 min using AP compared to the manually optimized plans, respectively.

Conclusion: The evaluated automated planning algorithm achieved highly consistent and significantly improved treatment plans with potentially clinically relevant OAR sparing by >20 % in 64 % of the cases. The effective working time was substantially reduced with Auto-Planning.

Keywords: Volumetric modulated arc therapy, Head and neck, Automated planning optimization

Introduction

Intensity modulated radiotherapy (IMRT) and volumetric modulated radiotherapy (VMAT) have been used for more than a decade and are now standard techniques for external beam radiotherapy treatment (RT). However, the inverse and computer-based planning approach involves multiple manual steps, which might influence the plan quality and consistency: planning objectives and constraints need to be manually adapted to the patient individual anatomy and tumor location, size and shape [1]. Additional help structures are frequently defined to further individualize and optimize the treatment plan on a patient individual basis resulting in an iterative process of IMRT and VMAT plan generation. Furthermore, the TPS operator needs to have profound knowledge and experience about the limitations of the treatment planning system and techniques, translating this into a prediction of the dose distribution, which can be achieved in each individual case. This method of manual optimization is time consuming, especially for complex cases such as head and neck carcinoma where multiple

* Correspondence: Jerome.krayenbuehl@usz.ch
[1]Department of Radiation Oncology, University Hospital Zurich, Klinik für Radio-Onkologie, Rämistrasse 100, CH-8091 Zürich, Switzerland
Full list of author information is available at the end of the article

BioMed Central

Pinnacle Auto-Planning: pubblicazioni recenti

- Pinnacle Auto-Planning per tecniche di pianificazione complesse

Krayenbuehl *et al. Radiation Oncology* (2017) 12:161
DOI 10.1186/s13014-017-0896-7

Radiation Oncology

RESEARCH Open Access

Improved plan quality with automated radiotherapy planning for whole brain with hippocampus sparing: a comparison to the RTOG 0933 trial

J. Krayenbuehl*, M. Di Martino, M. Guckenberger and N. Andratschke

Abstract

Background: Whole-brain radiation therapy (WBRT) with hippocampus sparing (HS) has been investigated by the radiation oncology working group (RTOG) 0933 trial for patients with multiple brain metastases. They showed a decrease of adverse neurocognitive effects with HS WBRT compared to WBRT alone. With the development of automated treatment planning system (aTPS) in the last years, a standardization of the plan quality at a high level was achieved. The goal of this study was to evaluate the feasibility of using an aTPS for the treatment of HS WBRT and see if the RTOG 0933 dose constraints could be achieved and improved.

Methods: Ten consecutive patients treated with HS WBRT were enrolled in this study. 10 × 3 Gy was prescribed according to the RTOG 0933 protocol to 92% of the target volume (whole-brain excluding the hippocampus expanded by 5 mm in 3-dimensions). In contrast to RTOG 0933, the maximum allowed point dose to normal brain was significantly lowered and restricted to 36.5 Gy. All patients were planned with volumetric modulated arc therapy (VMAT) technique using four arcs. Plans were optimized using Auto-Planning (AP) (Philips Radiation Oncology Systems) with one single AP template and optimization.

Results: All the constraints from the RTOG 0933 trial were achieved. A significant improvement for the maximal dose to 2% of the brain with a reduction of 4 Gy was achieved (33.5 Gy vs. RTOG 37.5 Gy) and the minimum hippocampus dose was reduced by 10% (8.1 Gy vs. RTOG 9 Gy). A steep dose gradient around the hippocampus was achieved with a mean dose of 27.3 Gy at a distance between 0.5 cm and 1 cm from the hippocampus. The effective working time to optimize a plan was kept below 6'.

Conclusion: Automated treatment planning for HS WBRT was able to fulfil all the recommendations from the RTOG 0933 study while significantly improving dose homogeneity and decreasing unnecessary hot spot in the normal brain. With this approach, a standardization of plan quality was achieved and the effective time required for plan optimization was minimized.

Keywords: Volumetric modulated arc therapy, Automated planning optimization, Whole brain irradiation, Hippocampus sparing, RTOG 0933

Pinnacle Auto-Planning: pubblicazioni recenti

- Pinnacle Auto-Planning unico strumento in grado di garantire un trattamento ETICO a TUTTI i pazienti

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ctRO Clinical and Translational Radiation Oncology

Original Research Article

Automatic treatment planning improves the clinical quality of head and neck cancer treatment plans

Christian Rønn Hansen [a,*], Anders Bertelsen [a], Irene Hazell [a], Ruta Zukauskaite [b,c], Niels Gyldenkerne [c], Jørgen Johansen [b,c], Jesper G. Eriksen [b,c], Carsten Brink [a,b]

[a] Laboratory of Radiation Physics, Odense University Hospital, Odense, Denmark
[b] Institute of Clinical Research, University of Southern Denmark, Odense, Denmark
[c] Department of Oncology, Odense University Hospital, Odense, Denmark

A R T I C L E I N F O

Article history:
Available online xxxx

Keywords:
Automatic
Treatment planning
Head and neck
VMAT
Pinnacle

A B S T R A C T

Background: Treatment plans for head and neck (H&N) cancer are highly complex due to multiple dose prescription levels and numerous organs at risk (OARs) close to the target. The plan quality is inter-planner dependent since it is dependent on the skills and experience of the dosimetrist. This study presents a blinded prospective clinical comparison of automatic (AU) and manually (MA) generated H&N VMAT plans made for clinical use.

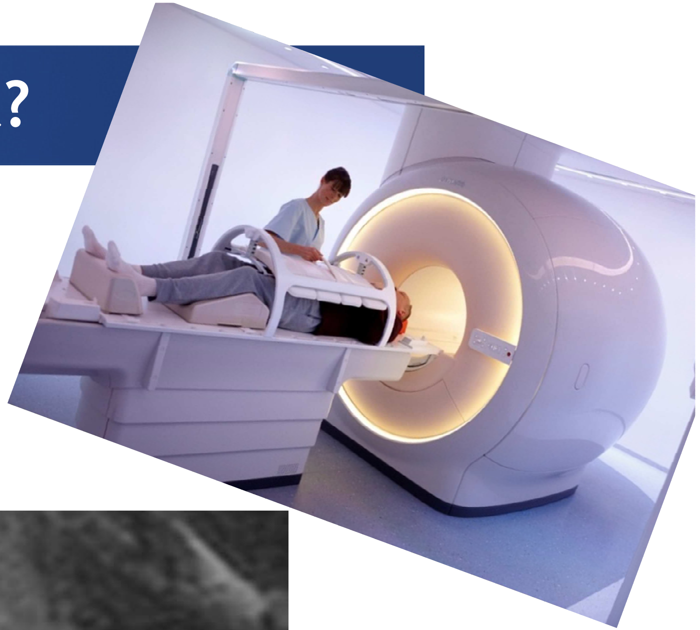
Methods: MA and AU plans were generated for 30 consecutive patients in Pinnacle[3] using the IMRT optimisation module and the new Autoplan module, respectively. The plan quality was blindedly compared by three senior oncologists and the best plan was selected for treatment of the patient. Planning time was measured as the active operator time used. The plan quality was analysed with DVH metrics and the dose delivery accuracy validated on the ArcCheck phantom.

Results: For twenty-nine out of the thirty patients the AU plan was chosen for treatment. Target doses were more homogenous with the AU plans and the OAR doses were significantly reduced, between 0.5 and 6.5 Gy. The average operator time spent on creating a manual plan was 64 min which was halved by Autoplan. The AU plans were more modulated as illustrated by an increase in MUs, which might cause the slightly lower pass rate of 97.7% in the ArcCheck measurements.

Conclusions: Target doses were similar between MA and AU plan, while AU plans spared all OAR considerably better than the MA plans.

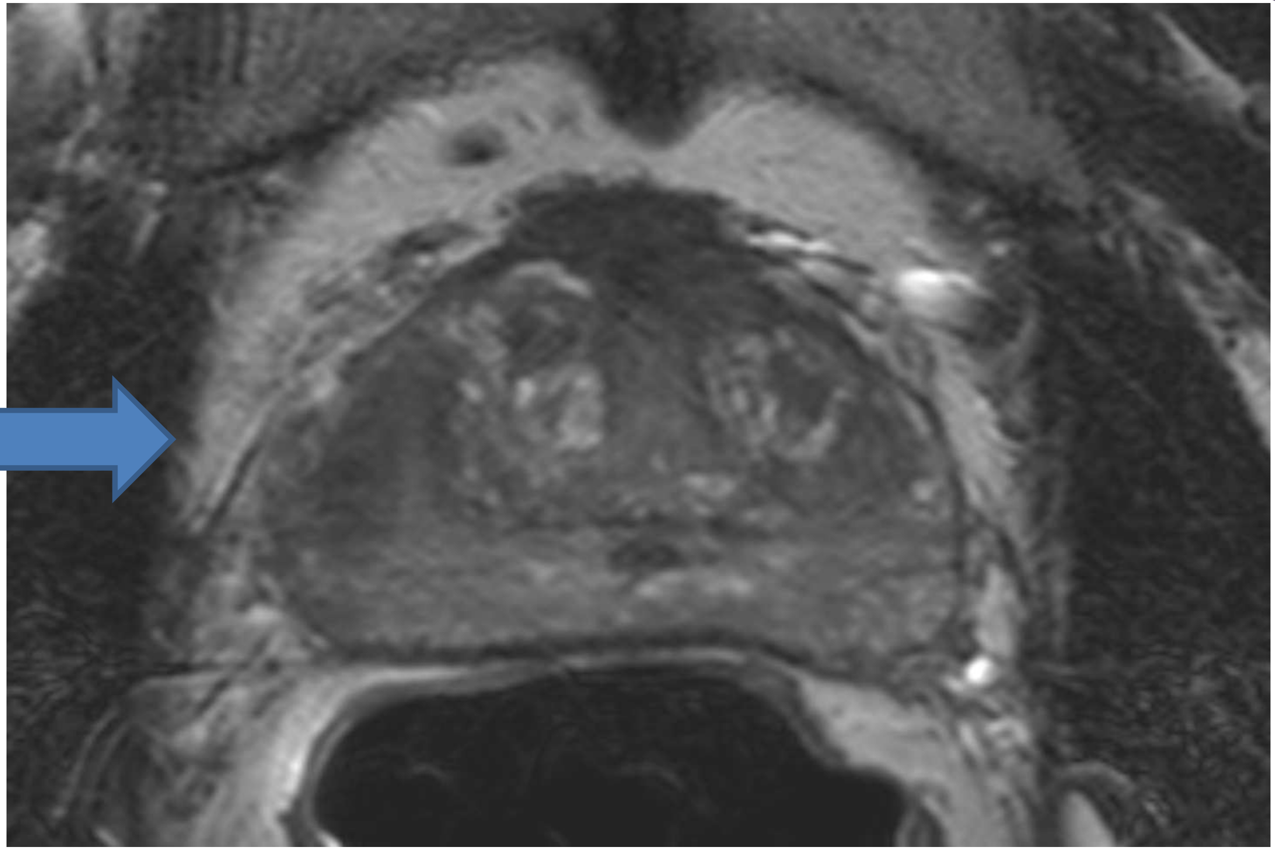
IGRT ed RMN: indiscussi protagonisti

Perché RMN in Radioterapia?



In base alla sequenza che utilizziamo, possiamo ottenere:

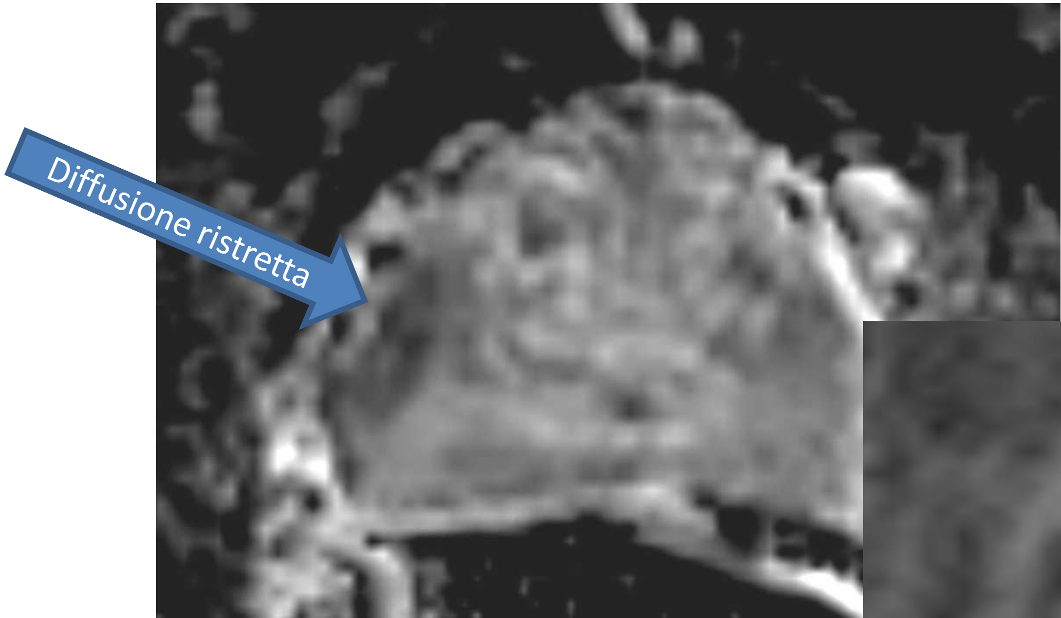
•**Informazioni morfologiche (T2W – T1W)**

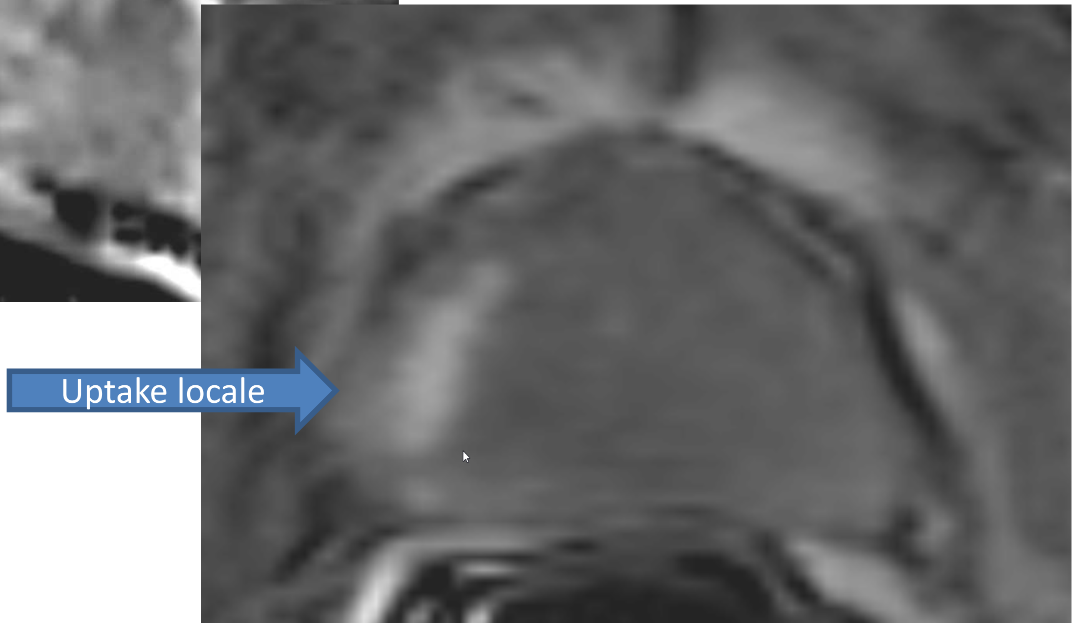


Perché RMN in Radioterapia?

In base alla sequenza che utilizziamo, possiamo ottenere:

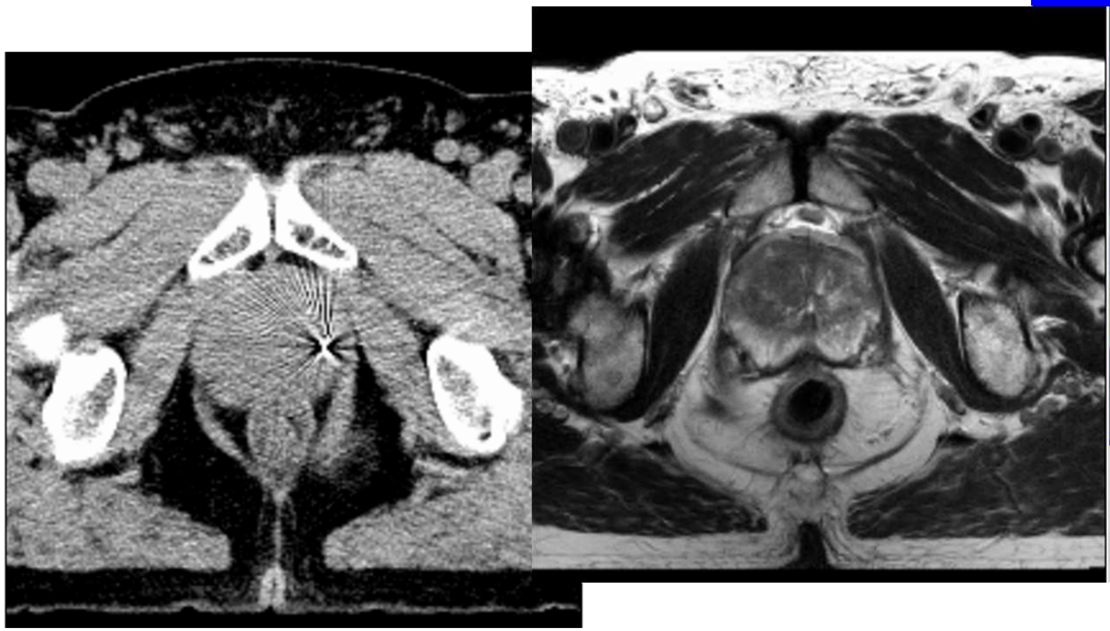
- Informazioni morfologiche (T2W – T1W)
- **Informazioni funzionali (DWI - DCE)**

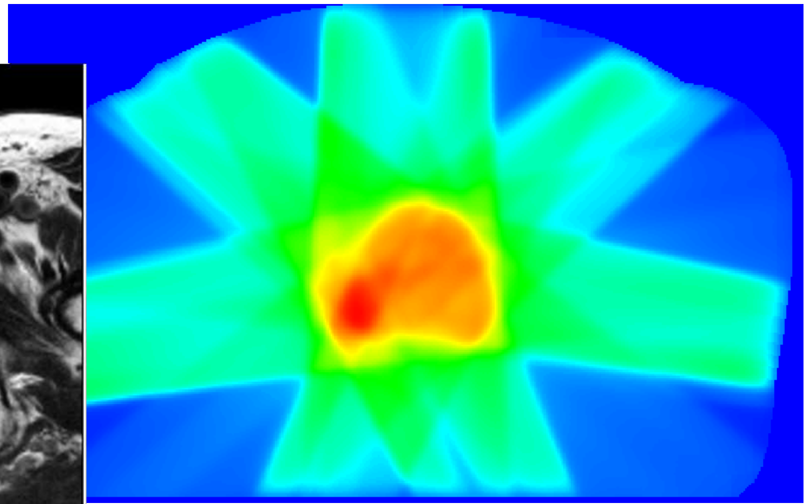




Perché RMN in radioterapia?

- Accuratezza nella definizione del target
- Valutazione interessamento della capsula e definizione CTV
- Boost al tumore





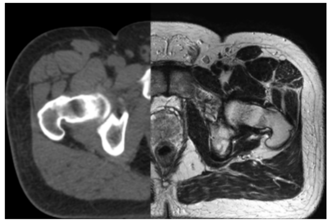
La RMN nella Radioterapia odierna

- Eccellente qualità e risoluzione di contrasto a supporto del planning CT-based

Simulazione RMN

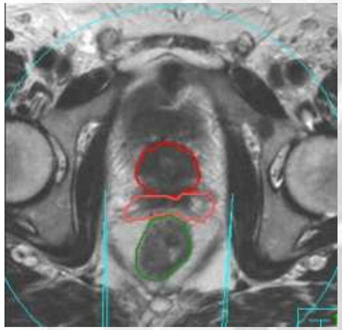
Simulazione CT

Contrasto tessuti molli

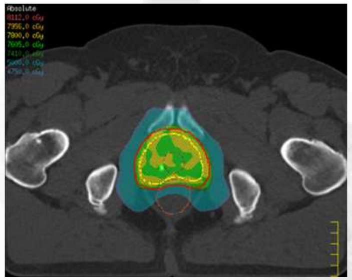


Registrazione RMN-CT

Informazione di densità (Hounsfield Units)



Delineazione del target



Calcolo della dose

Piano di trattamento ed erogazione

Il potenziale delle applicazioni di RMN oggi

- Ricerca, industria, diagnostica,…ma si può andare oltre?

PHILIPS HEALTHCARE: soluzioni in Radiation Oncology

Philips Healthcare

Radiation Oncology

Improved Outcomes (Accuracy)	Improved Workflow (Efficiency)	Optimized economic value	Maximized productivity




Sales & services geographies

North America	International	Emerging Markets
		
51%	36%	13%

1000+
People employed worldwide in over 100 countries

26%
of global sales invested in R&D

2500+
Pinnacle[3] installations world-wide

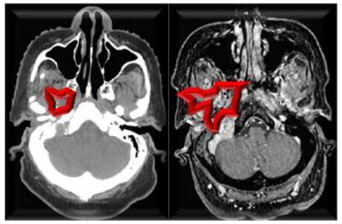
900+
Big Bore CT installations world-wide

PHILIPS HEALTHCARE: sinergia fra imaging e trattamento

CT BB

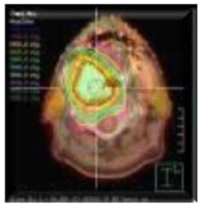
Eccellente Qualità di Immagine

MR RT



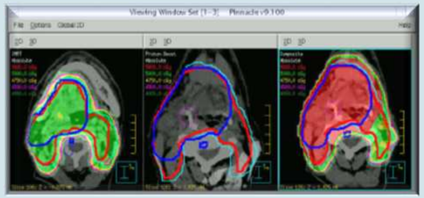
Soluzione dedicata per il planning ed il follow-up in RT

PET-CT BB



Ricostruzione 4x più veloce

Pinnacle^3



Best-in-Class Simulation & Treatment Planning Solution

Architettura flessibile e scalabile

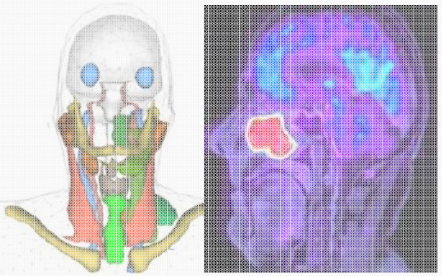
Un nuovo approccio: l’informazione del trattamento

- **Automatizzazione intelligente** del workflow ed **integrazione** delle fasi di lavoro

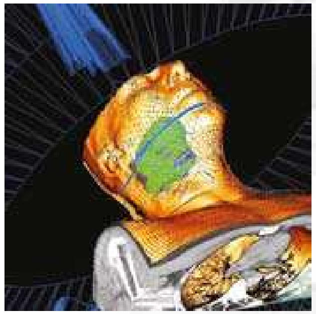
Adattamento del piano di trattamento

IMAGING → **INFORM** → **TARGET** → **TRATTAMENTO**

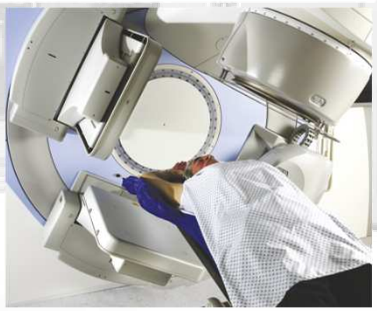
Simulazione
per ogni piano di trattamento



Apply tumor characterization
& organ risk knowledge



~ 4 ore planning
~ 3 giorni trascorsi



5 EBRT frazioni/settimana
~ 6 settimane

1D Segnale → **2D** Immagine → **3D** Volume → **4D** Tempo → **5D** Informazione significativa → **6D** Integrazione Intelligente

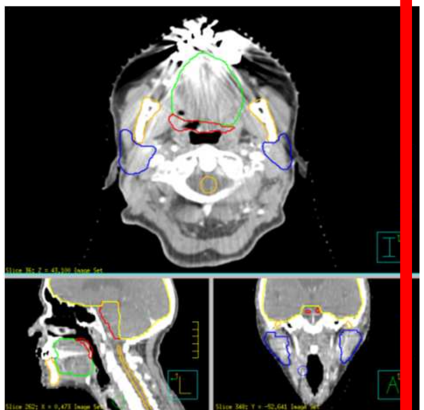
Pinnacle³: ottimizzazione del workflow

Pre-planning (contornazione) → Planning → Valutazione ed approvazione → Ri-valutazione per adaptive e re-planning

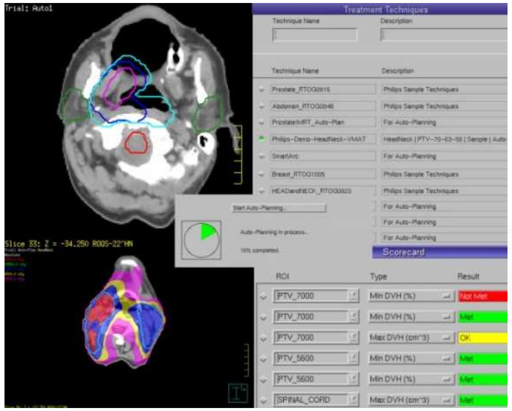
Ottimizzazione dei tempi di contornazione

Ottimizzazione dei tempi di pianificazione e valutazione

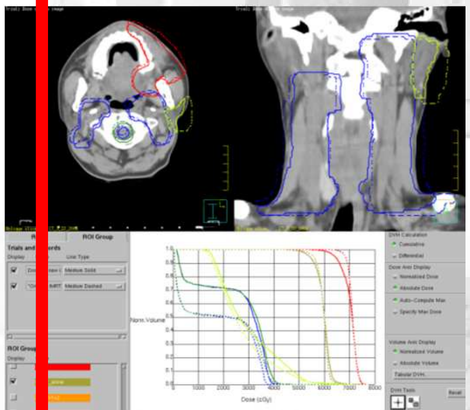
Ottimizzazione dei tempi di ri-valutazione in corso di trattamento e di re-planning



SPICE



Auto-Planning



Dynamic Planning

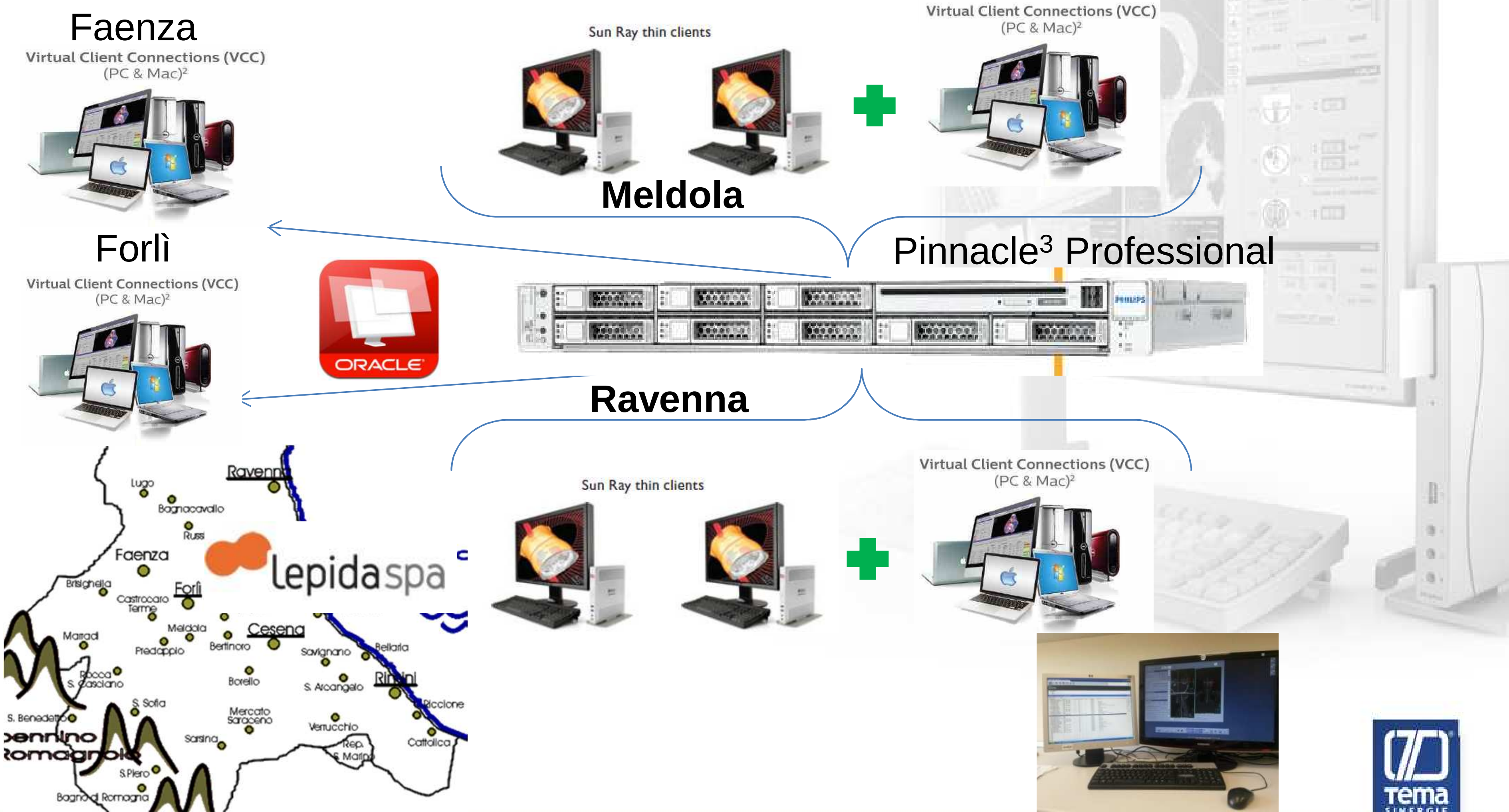
CRITICITA' NELLA PIANIFICAZIONE DEL TRATTAMENTO: CENTRALIZZAZIONE

- Architettura HW a server centralizzato
  - drastica riduzione dei tempi di calcolo
  - abbattimento dei tempi e dei costi di pianificazione

Professional

Esperienze in rete

- Accesso distribuito, facilitato e rapido alle risorse di pianificazione



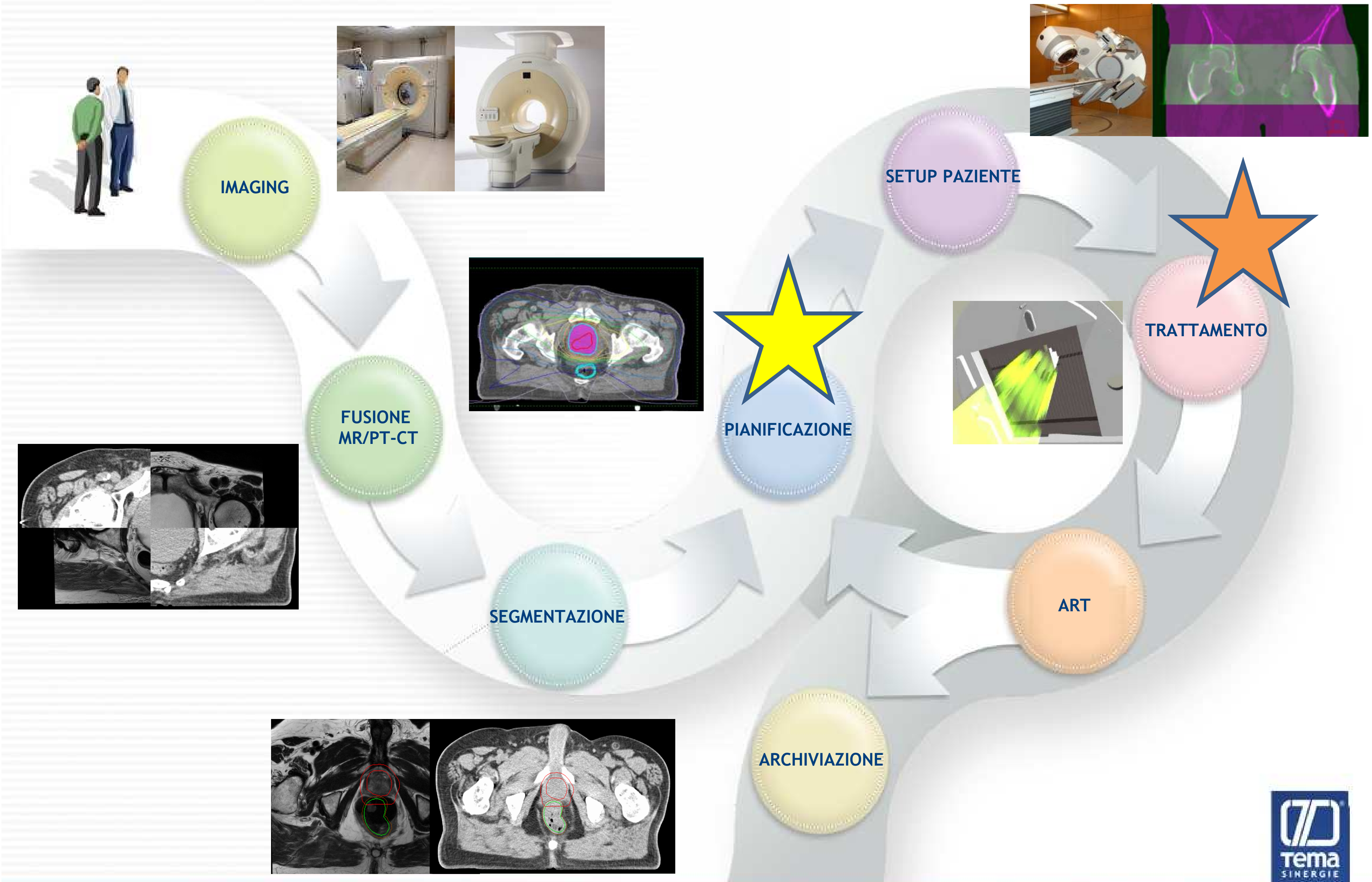
CRITICITA' NELLA PIANIFICAZIONE DEL TRATTAMENTO: CONCLUSIONI

- La complessità delle tecniche di trattamento radioterapiche attuali richiede
  - piani di trattamento il più consistenti possibile
  - in tempi contenuti
  - con caratteristiche di qualità di primo livello

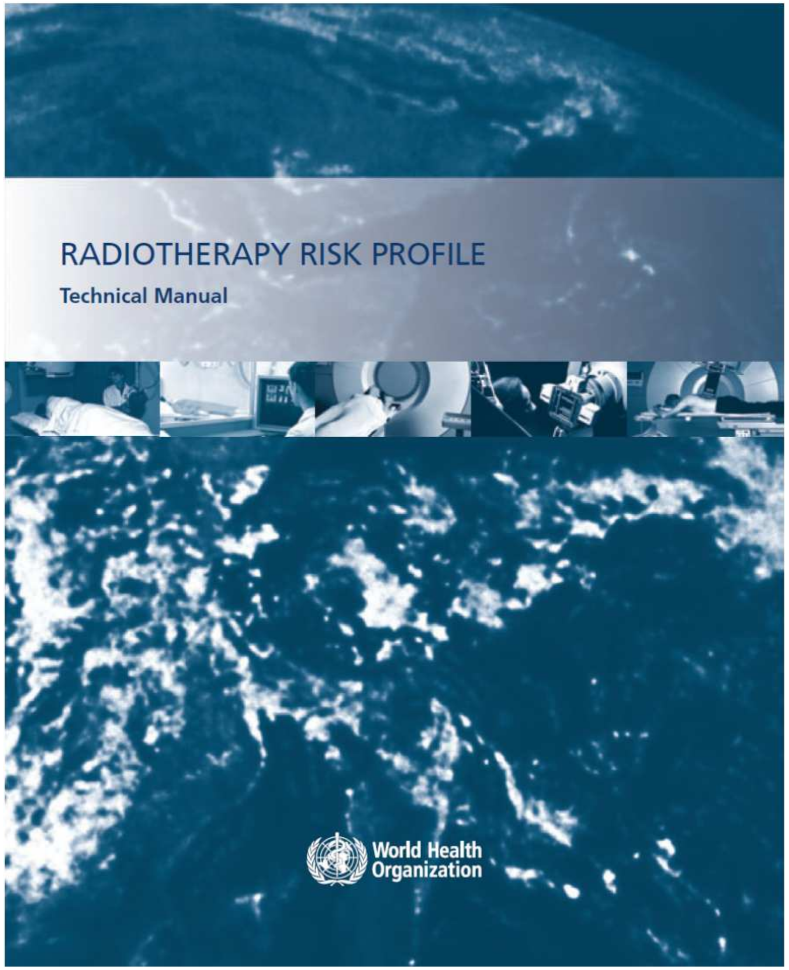
- Per ottenere questi risultati è necessario
  - automatizzare il più possibile le procedure ripetitive, laboriose e time-consuming della pianificazione clinica
  - sfruttare l'esperienza acquisita
  - standardizzare le attività di pianificazione e di valutazione

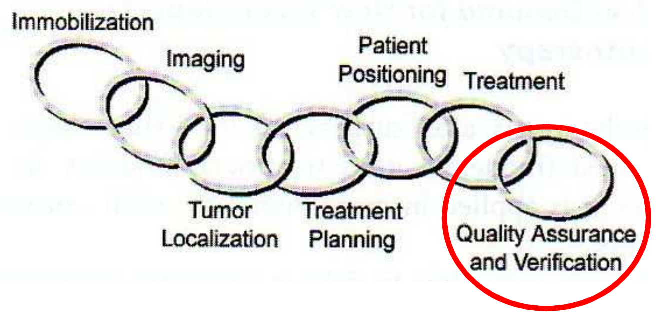
Pinnacle Auto-Planning è l'unico sistema di pianificazione automatica in grado di garantire un trattamento ETICO a tutti i pazienti indistintamente

Il flusso di lavoro della moderna Radioterapia: CRITICITA’



Risk management e QA in Radioterapia





gestione del rischio clinico

prevenzione

sicurezza

incidenti

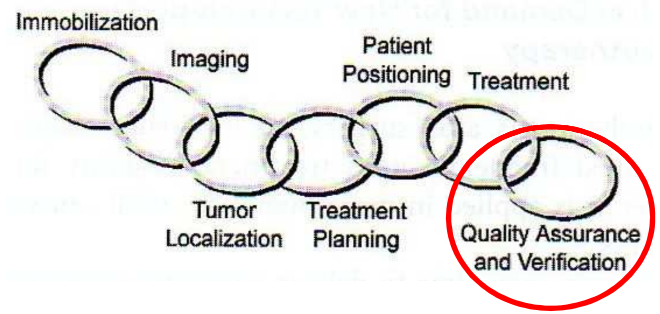
sentenze

Risk management e QA in Radioterapia

Table 5:
Treatment processes and identification of the professional groups responsible for each process.

Stage	Description	Responsibility RO	RT	MP
1 Assessment of patient	History taking, physical examination, review of diagnostic material	•		
2 Decision to treat	Consideration of guidelines, patient wishes	•		
3 Prescribing treatment protocol	Determination of site, total dose, fractionation and additional measures such as dental review or concurrent chemotherapy	•		
4 Positioning and immobilization	Setting up the patient in a reproducible position for accurate daily treatment		•	
5 Simulation, imaging and volume determination	Determining region of the body to be treated using diagnostic plain X-ray unit with the same geometry as a treatment unit (simulator) or dedicated CT scanner	•	•	
6 Planning	Determining X-ray beam arrangement and shielding then calculating dose to achieve prescription		•	•
7 Treatment information transfer	Transfer beam arrangement and dose data from treatment plan to treatment machine		•	•
8 Patient setup	Placing patient in treatment position for each treatment		•	
9 Treatment delivery	Physical delivery of radiation dose		•	•
10 Treatment verification and monitoring	Confirmation of treatment delivery using port films and dosimeters Monitoring of the daily setup Monitoring of tolerance by regular patient review	•	•	•

Note: Professions responsible for process stages vary between countries



Risk management e QA in Radioterapia

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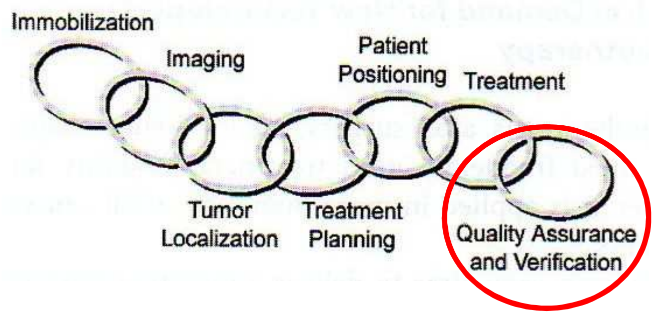
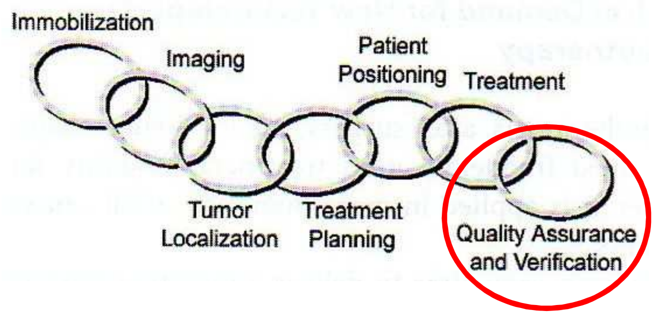


Risk management e QA in Radioterapia

4. Positioning and immobilization

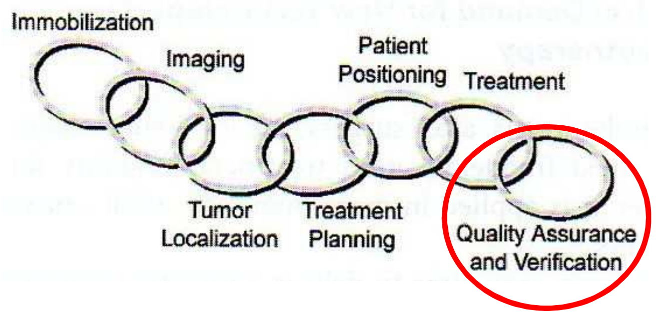
Risks	Potential impact	Solutions
Patient-related factors – co-morbid disease, inability to comply with instructions	Medium	Patient selection Comprehensive assessment and documentation of difficulties
Incorrect patient positioning	High	Planning protocol checklist Independent checking Adequate staffing levels and education In vivo dosimetry
Different positioning for different imaging modalities	Medium	
Incorrect immobilization position	Medium	
Wrongly applied immobilization device	Medium	
Inaccurate transfer of prescription	High	



Risk management e QA in Radioterapia

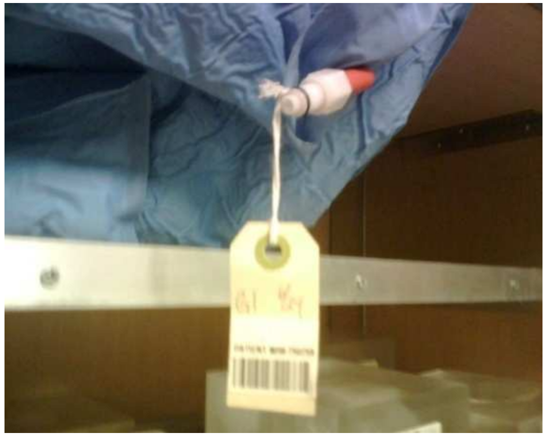
8. Patient setup

Risks	Potential impact	Solutions
Incorrect identification of patient	High	ID check open questions, eliciting an active response as a minimum 3 points of ID Photo ID
Failure to assess patient's current medical status	Medium	Competency certification Appropriate education and staffing levels
Wrong position Wrong immobilization devices Wrong side of body (left/right) Incorrect isocentre Incorrect use or omission of accessories Incorrect treatment equipment accessories Missing Bolus	High Medium High High High High High	Independent checking and aids to setup
Unnecessarily complex setup limiting reproducibility	High	Machine protocol check Treatment protocols Peer review audit
Patient changing position during setup	High	Visual monitoring during treatment



Criticità nel riconoscimento del paziente: Xecan Smart RFID

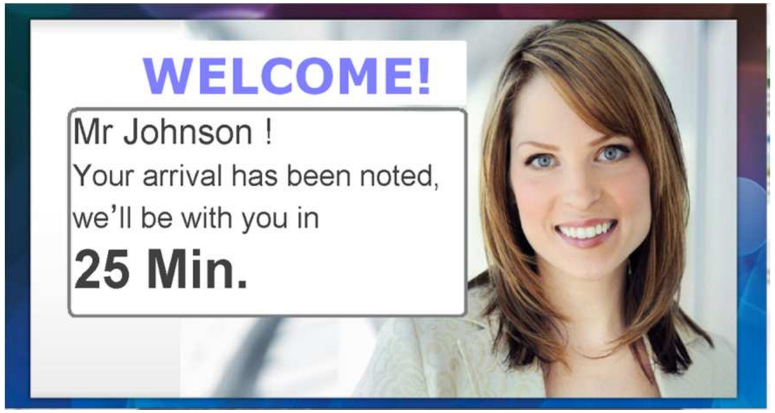
- Una soluzione proposta finora: i sistemi codici a barre
- …ma:
  - richiedono lettori da impugnare manualmente
  - comportano tempi aggiuntivi per l’utilizzo
  - … in generale sono poco pratici



Criticità nel riconoscimento del paziente: Xecan Smart RFID

- **Cosa può fare?**
  - **può tracciare in tempo reale ed in modo wireless la presenza e la posizione di tutte le persone (pazienti, personale, …) e di tutti gli "oggetti" (dispositivi posizionamento paziente, blocchi personalizzati, cartelle cliniche cartacee, film, …) dotati di apposito dispositivo di riconoscimento "RF tag"**

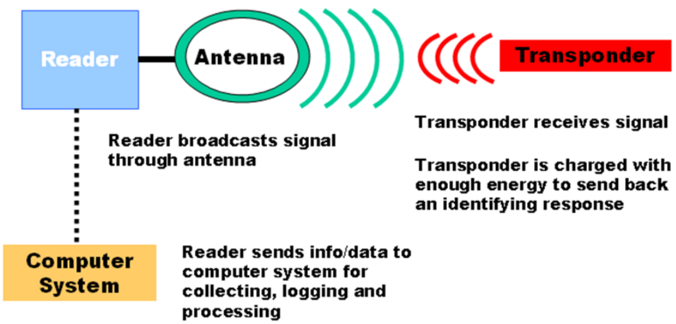
Smart RFID Oncology
Xecan



Tema SINERGIE

Criticità nel riconoscimento del paziente: Xecan Smart RFID

- Come funziona?
  - tecnologia RFID (Radio Frequency IDentification): permette l'identificazione a distanza di oggetti e persone, grazie a particolari etichette a radiofrequenza (dette anche “smart labels”, “transponders” o “tags”)
  - <u>totale integrazione con gli attuali Sistemi R&V</u>

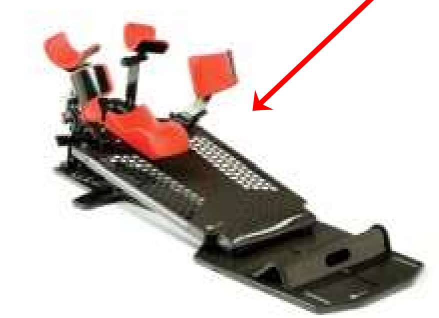


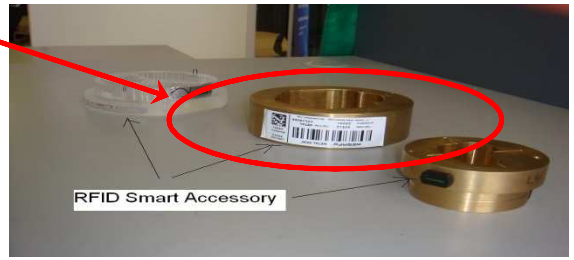
Criticità nel riconoscimento del paziente: Xecan Smart RFID

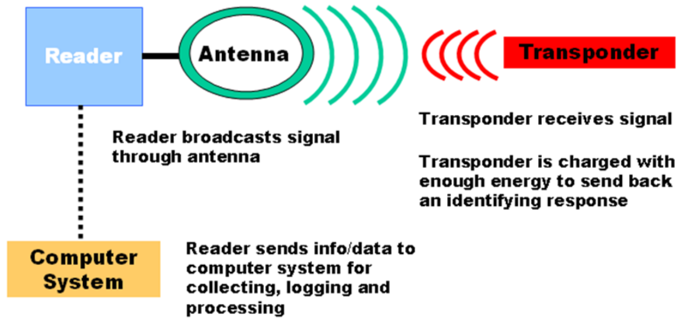
- **Come funziona?**

Smart RFID Oncology
Xecan

RF tag







Xecan Smart RFID: tecnologie disponibili

- **Riconoscimento a distanza**

- **Riconoscimento biometrico (*palm vein pattern recognotion*)**

Xecan Smart RFID: componenti del sistema

- **Quali sono le componenti del sistema?**
  - **RF tag = componente passivo (quindi senza necessità di essere alimentato, ad esempio tramite batterie) miniaturizzato come etichetta adesiva, che "risponde" via RF quando "interrogato" da un'apposita antenna (gli RF tag necessari possono essere stampati in automatico tramite una specifica stampante)**

Smart RFID Oncology

Xecan

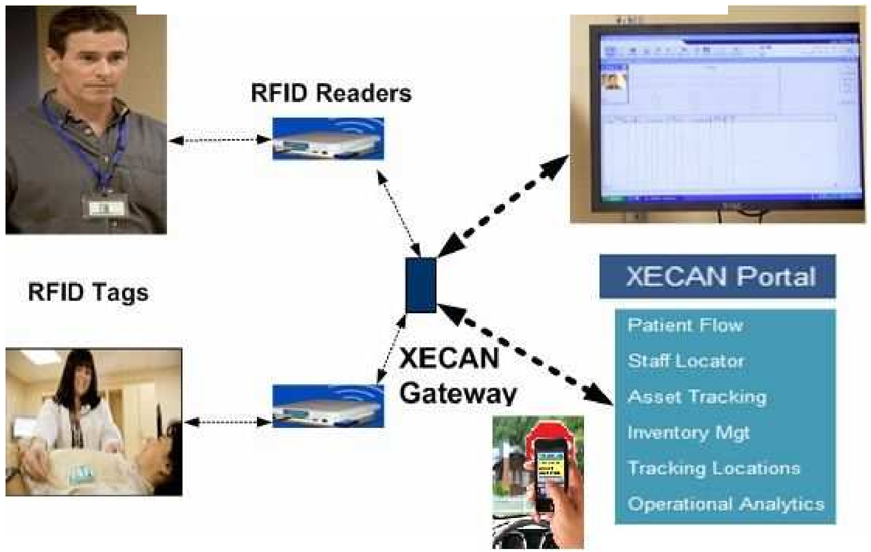
Tema SINERGIE

Xecan Smart RFID: componenti del sistema

- Quali sono le componenti del sistema?
  - portale
  - lettore da tavolo

  - lettore / antenna al soffitto

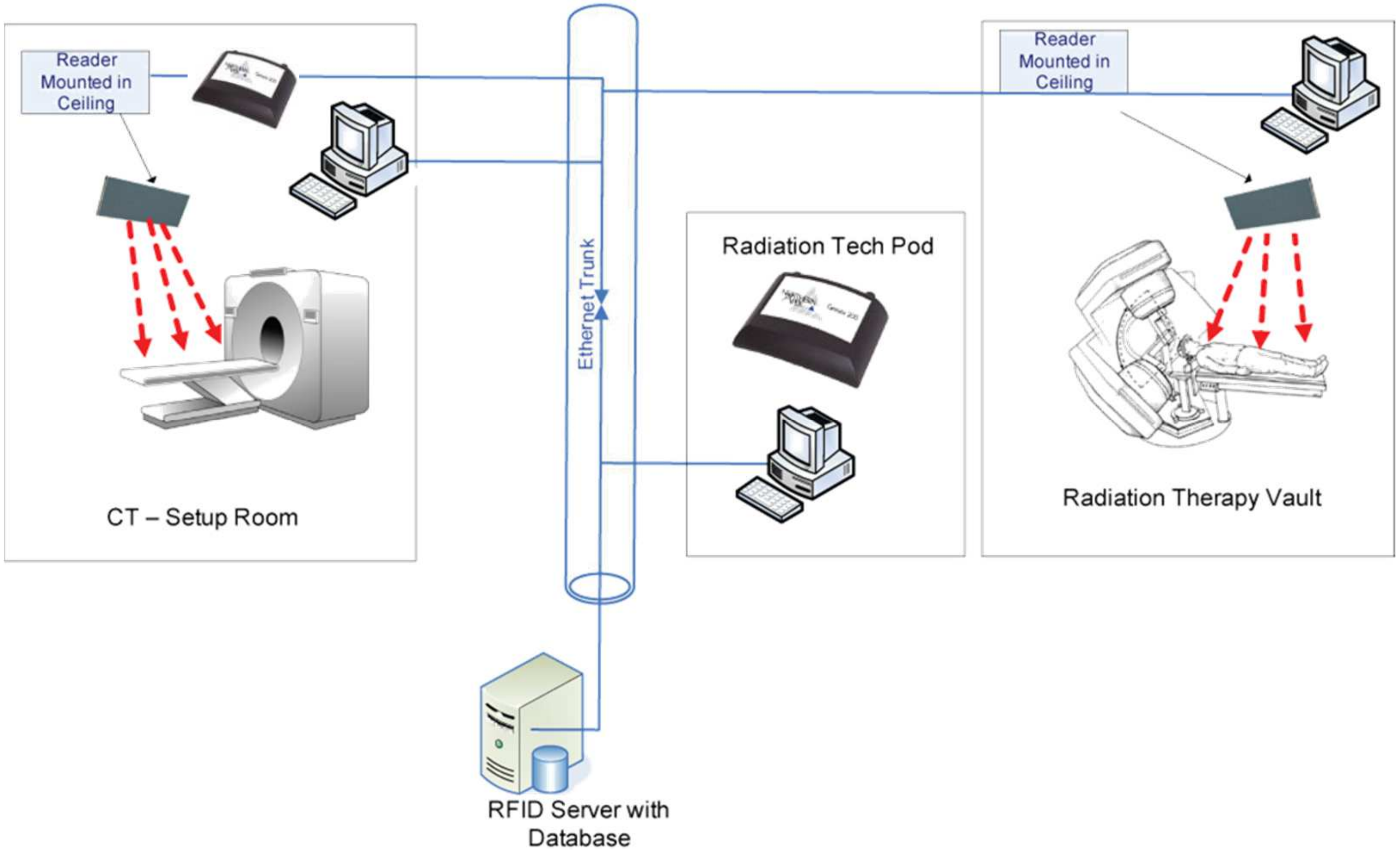
Smart RFID Oncology
Xecan



Xecan Smart RFID nel Reparto

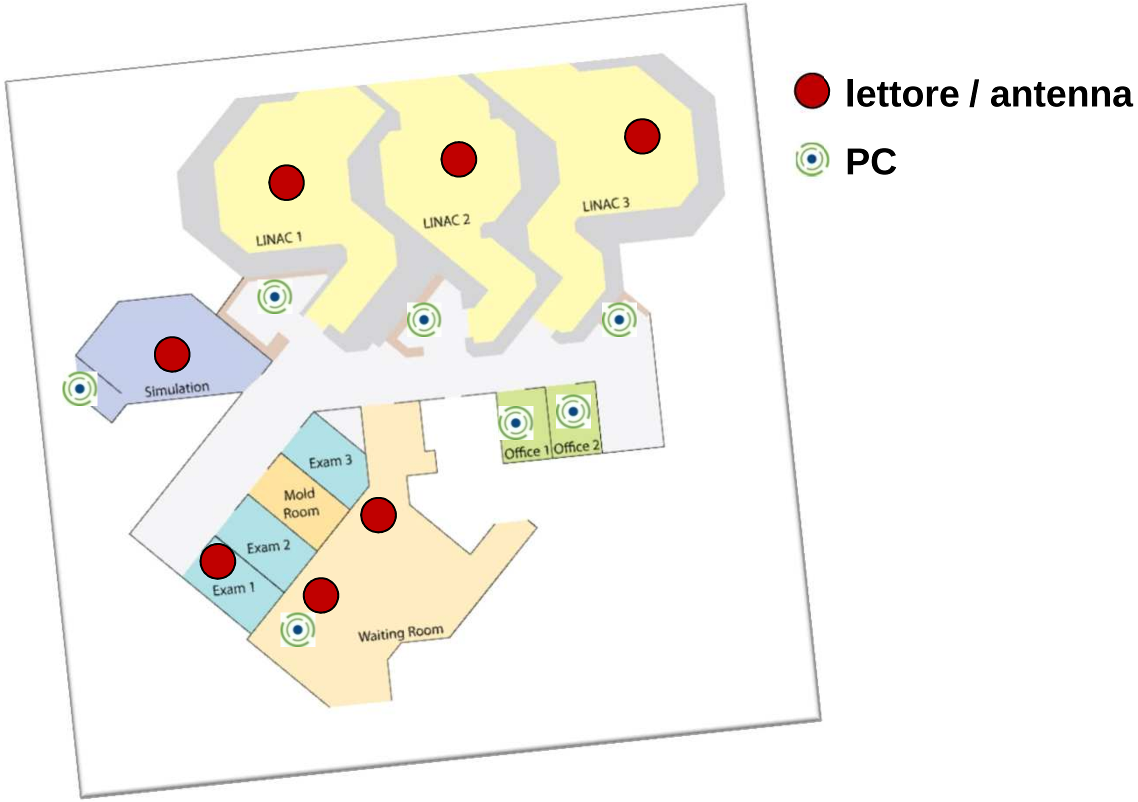
- **Come viene integrato nel reparto?**

Smart RFID Oncology
Xecan



Xecan Smart RFID nel Reparto

- **Come viene integrato nel reparto?**



Xecan Smart RFID: workflow

- Come avviene il check-in del paziente?
  - il paziente si presenta con un badge / braccialetto dotato di RF tag
    - l'accettazione può essere dotata di lettore da tavolo a corto raggio oppure di lettore / antenna al soffitto, utile comunque per il monitoraggio della sala d'attesa
  - oppure, ne viene scansionato il palmo della mano
    - il pattern venoso (unico) del palmo della mano del paziente viene codificato in un file digitale protetto e crittografato condiviso con il R&V
    - il lettore è un sistema robusto che effettua una scansione subito sotto la superficie della pelle
  - <u>il R&V mette automaticamente in coda il paziente per il trattamento</u>

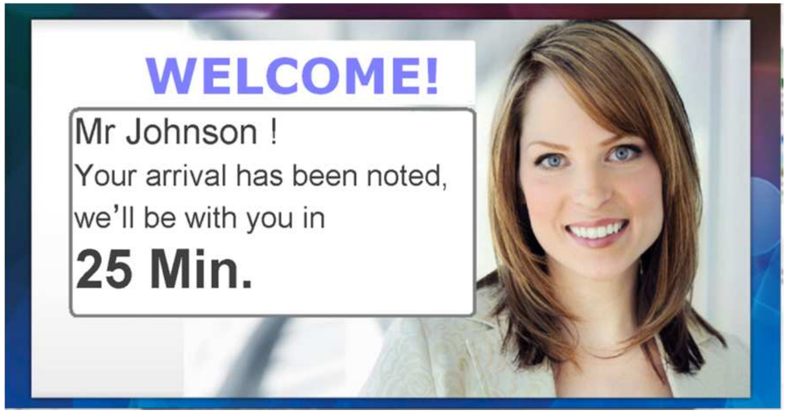
Smart RFID Oncology

Xecan

Xecan Smart RFID: workflow

- Come avviene il check-in del paziente?
  - per ogni paziente, viene fornita una stima del tempo di attesa
  - sullo schermo d'accoglienza, viene indicato lo stato di occupazione delle sale di trattamento

Treatment Room Status			8/13/2013 On Treatment Visits
	STATUS	TIME	
Tx1	On Time		Dr.Mckee
Tx2	On Time		Dr.Mak
Tx3	Delayed	25 Min.	Dr.Mauser
Tx4	On Time		



Xecan Smart RFID: workflow

- **Come avviene il check-in del paziente?**
  - **possibilità di alert automatici su SmartPhone basati su eventuali ritardi dell'attività clinica**

Xecan Smart RFID: workflow

- **Come avviene la simulazione?**
  - **riconoscimento automatico del paziente mediante RF tag (badge / braccialetto) o scansione biometrica**
  - **tutti i dispositivi di posizionamento dotati di RF tag e posti sul lettino dello scanner CT vengono automaticamente riconosciuti, decodificati ed elencati**
  - **il TSRM è tenuto a confermare la presenza di ciascun dispositivo elencato, indicando eventuali sistemi specifici del particolare paziente in oggetto**
  - **ora è possibile salvare <u>nel Sistema R&V</u> il setup di simulazione per ciascun paziente, che sarà disponibile per i trattamenti successivi**

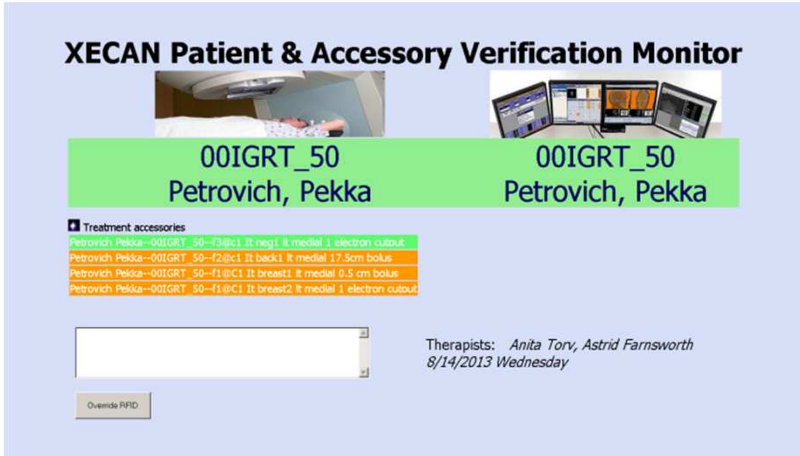
Smart RFID Oncology
Xecan

Xecan Smart RFID: workflow

- **Come avviene il trattamento?**
  - **riconoscimento automatico del paziente mediante RF tag (badge / braccialetto) o scansione biometrica**
  - **tutti i dispositivi di posizionamento dotati di RF tag e posti sul lettino del LINAC vengono automaticamente riconosciuti, decodificati ed elencati**
  - **il Sistema R&V avvisa in caso di differenze (dispositivi in eccesso / difetto, non corretti, ...) rispetto a quanto registrato durante la simulazione**
    - **Interlock di sicurezza con inibizione del trattamento**

Smart RFID Oncology

Xecan



Xecan Smart RFID: tracking real-time web-based

Smart RFID Oncology Xecan

Smart RFID Exam Room Whiteboard IN OUT

	Patient -- Wait Time (Min.)	Attending	Nurse -- Duration (Min.)	Dr. -- Duration (Min.)	Notes
E1	H. LONG -- 20	Conner	Williams -- 10	Who -- 9	
E2	P. PANAS -- 34	Daguerre	Brown -- 23	Wong -- 11	Waiting to see nutritionist
E3	J. XIAO -- 24	Valdez	Williams -- 24	--	
E4	--		--	--	
E5	V. KHAN -- 9	Banner	Bethencourt -- 9	Wong -- 1	
E6	--		--	--	Exam 6 closed for electrical work

Xecan Smart RFID: tracking real-time web-based

Smart RFID Oncology
Xecan

Tema SINERGIE

Xecan Smart RFID: analisi ed ottimizzazione

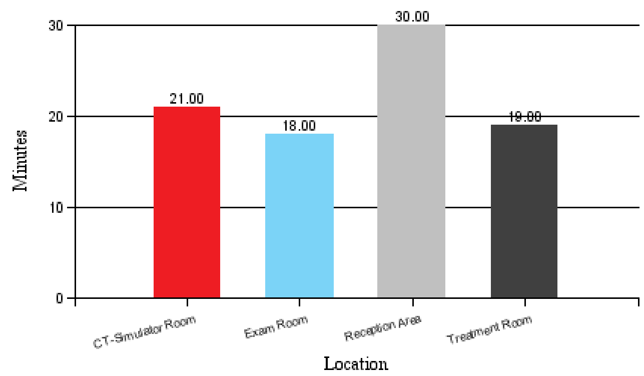
Smart RFID Oncology

Xecan

Date Range (mm/dd/yyyy):

02/05/2012 02/13/2012

SUBMIT



Result List

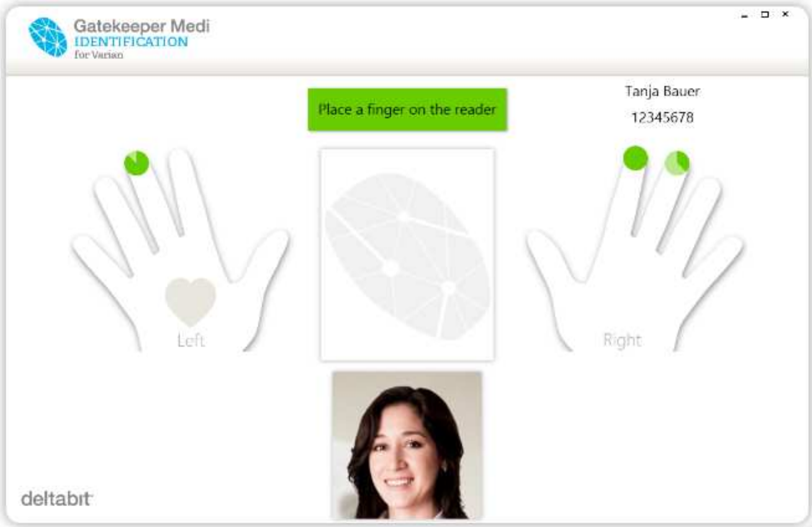
Location	Avg_wait_min
CT-Simulator Room	21
Exam Room	18
Reception Area	30
Treatment Room	19
Total	88

Tema SINERGIE

Criticità nel riconoscimento del paziente: Deltabit, un approccio alternativo

Deltabit: l'azienda

- Know-how focalizzato sul riconoscimento della persona
  - in aziende
  - in contesti domestici
  - <u>in healthcare (oltre due milioni di identificazioni paziente, nessun errore)</u>
  - partner del progetto europeo Fastpass di controllo automatico dell'identità alle frontiere
- Esperienza
  - di 20 anni nello sviluppo software
  - di 15 anni nel riconoscimento delle impronte digitali
  - di 10 anni nell'identificazione del paziente



Deltabit: il riconoscimento basato su impronte digitali

- Vantaggi
  - unicità
  - care-free
    - non possono essere perdute o dimenticate
  - sicurezza
    - ad essere salvato sono solo marker identificativi codificati, non l’immagine dell’impronta

- Metodologia consolidata
  - smartphones
  - controllo degli accessi
  - convalida di pagamenti
  - registrazione di votazioni
  - …

Deltabit: il riconoscimento basato su impronte digitali

- **Il principio di funzionamento**

Lettore

Sensore

"Cattura l'immagine"

Algoritmo

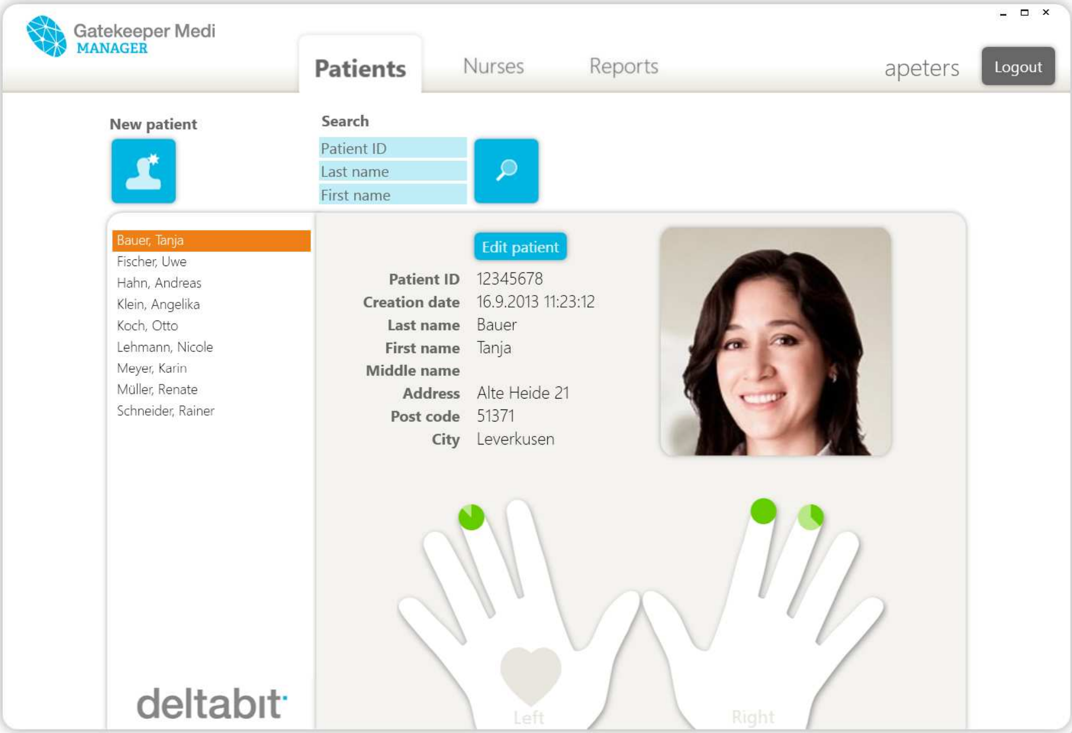
"Interpreta l'immagine"

Database

"Contiene i template numerici"

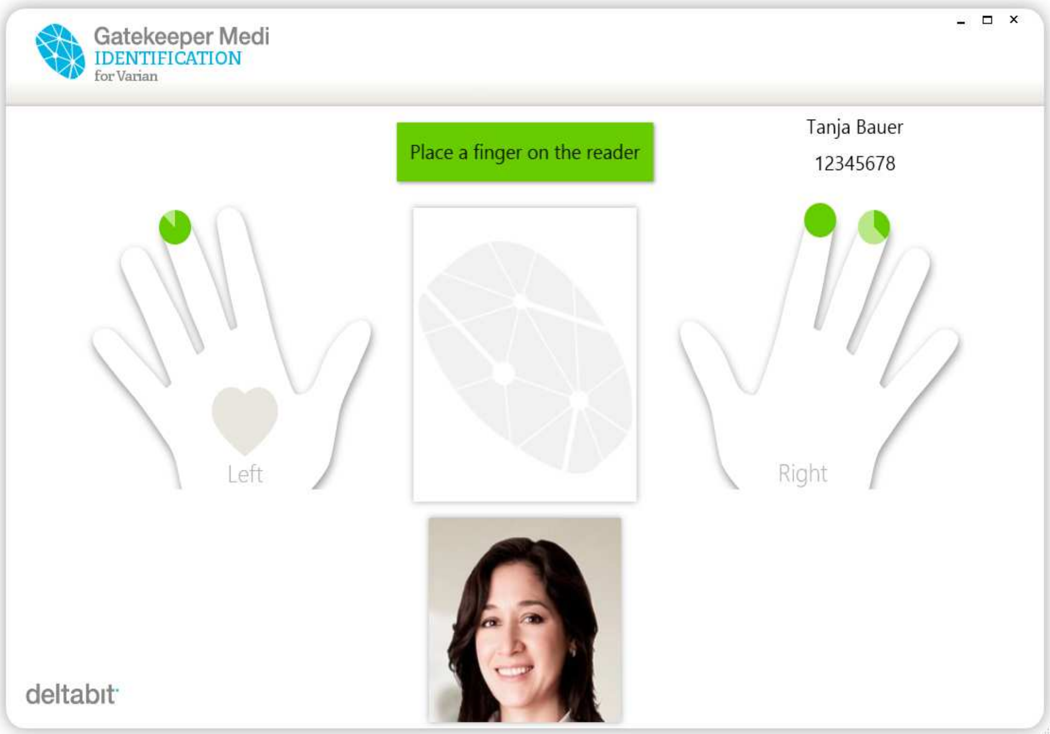
Deltabit: registrazione

- semplice gestione dei dati paziente
- visualizzazione grafica delle impronte salvate per una più agevole identificazione
- possibilità di un livello di sicurezza addizionale (fotografia del paziente)



Deltabit: identificazione

- **accurata: la scheda del paziente viene attivata in automatico per l'identificazione all'apertura del piano di trattamento del paziente stesso sull'OIS**
- **sicura: l'erogazione è consentita solo in caso di identificazione positiva**



Deltabit: check-in

- check-in
  - prenotazione *self service* per un appuntamento
  - uso dell'impronta digitale registrata, oppure di un codice a barre o di un codice alfanumerico

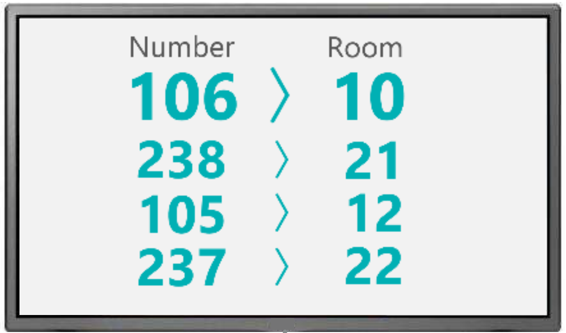
- chiamata
  - sufficiente un click per il personale in fase di chiamata
  - possibilità di aggiungere messaggi per i pazienti in check-in

- accodamento
  - messaggi specifici della sala dopo il check-in
  - indicazioni verso la corretta sala di trattamento

- tracciatura
  - possibilità di controllare la posizione corrente
  - storico delle attività di visita

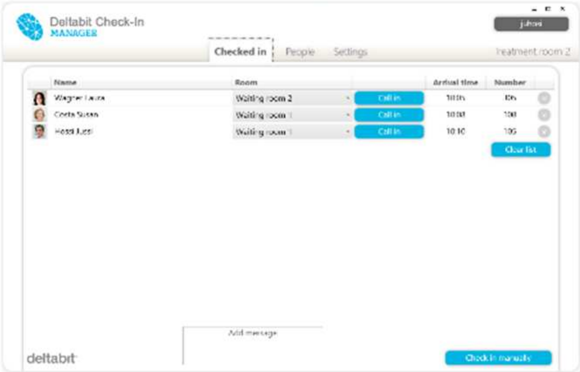
Deltabit: l'architettura del sistema

Display informativi



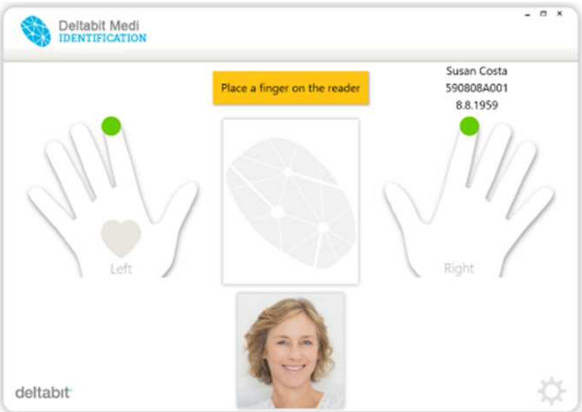
Terminali di check-in

Moduli di gestione

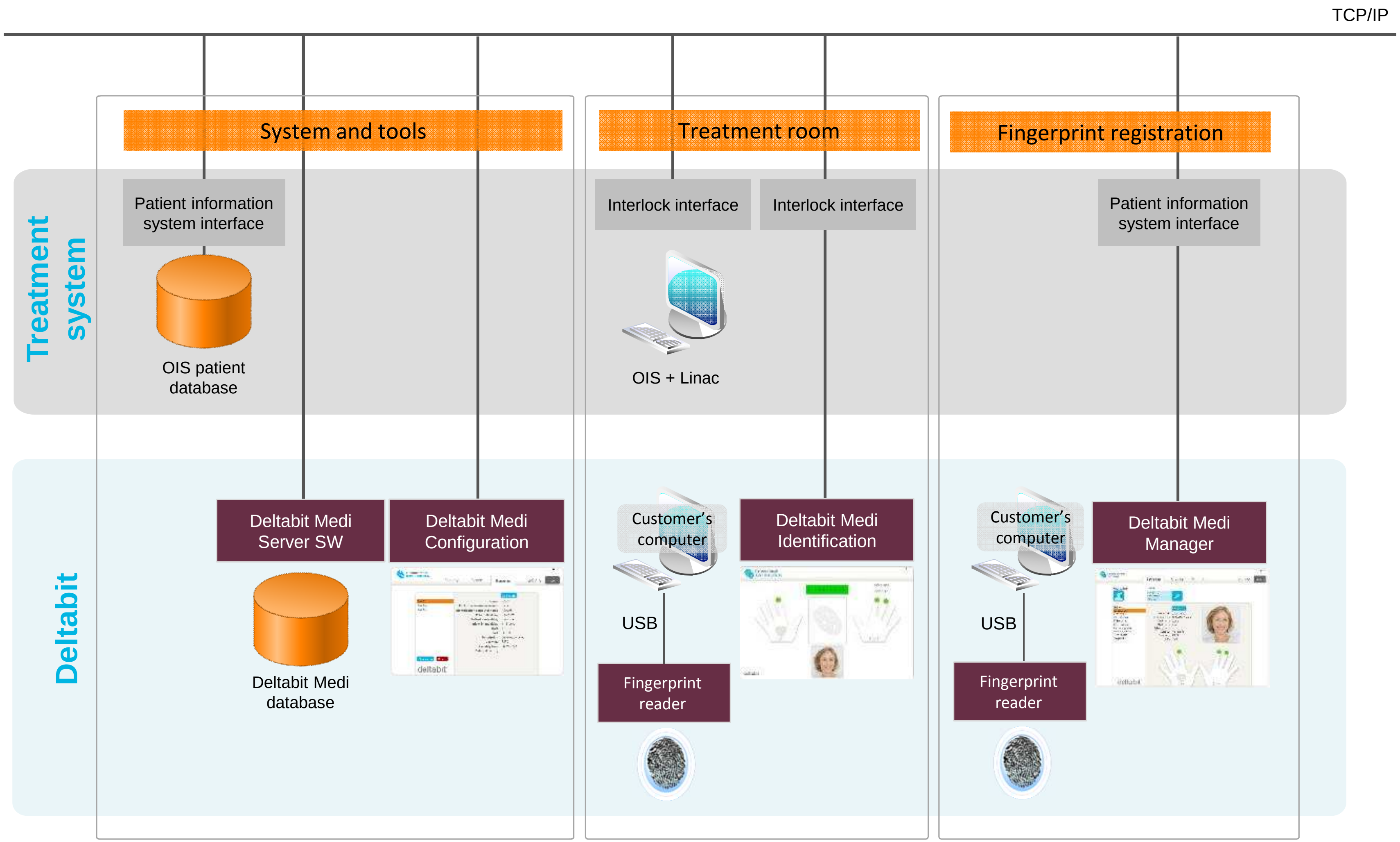


Server
e
Database
Deltabit

Moduli di identificazione

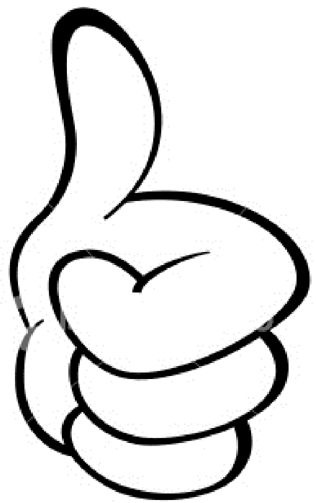


Deltabit: l’architettura del sistema



Criticità nel riconoscimento del paziente: conclusioni finali

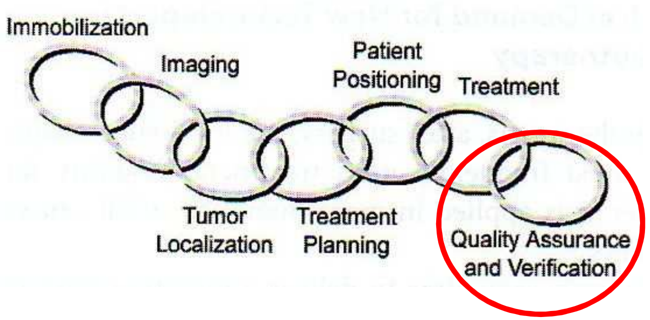
- **Quali sono i vantaggi principali?**
  - **effettiva implementazione protocolli di risk management e QA in Radioterapia: riduzione della percentuale di errore**
  - **+ efficienza: risparmio di tempo, sia per il personale sia per i pazienti, dovuto alla conoscenza della presenza / posizione di oggetti e persone nel reparto, tecnologia “hands free”**
  - **+ tutela della privacy del paziente**
  - **reports per documentazione elettronica e/o cartacea**



Risk management e QA in Radioterapia

8. Patient setup

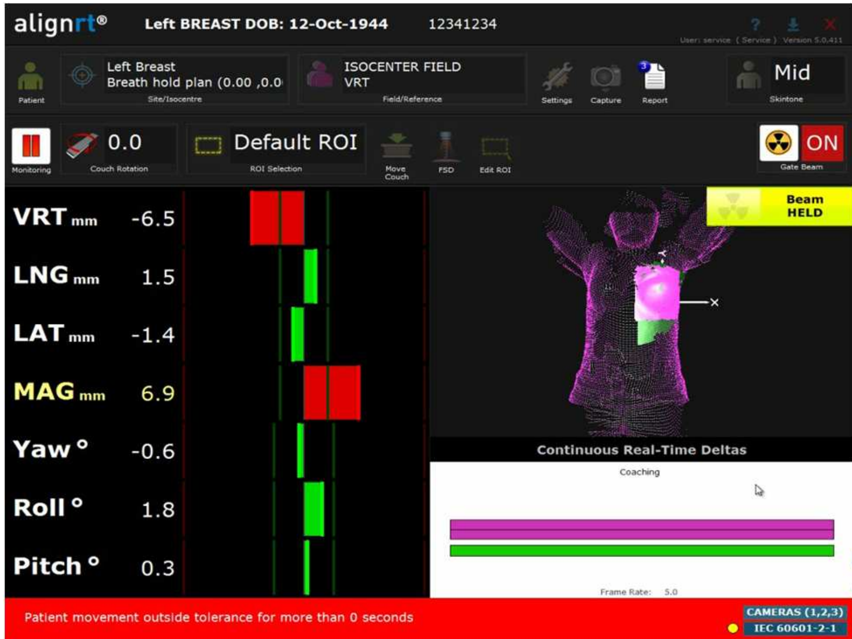
Risks	Potential impact	Solutions
Incorrect identification of patient	High	ID check open questions, eliciting an active response as a minimum 3 points of ID Photo ID
Failure to assess patient's current medical status	Medium	Competency certification Appropriate education and staffing levels
Wrong position Wrong immobilization devices Wrong side of body (left/right) Incorrect isocentre Incorrect use or omission of accessories Incorrect treatment equipment accessories Missing Bolus	High Medium High High High High High	Independent checking and aids to setup
Unnecessarily complex setup limiting reproducibility	High	Machine protocol check Treatment protocols Peer review audit
Patient changing position during setup	High	Visual monitoring during treatment



Criticità nel controllo on-line del setup del paziente: SGRT, la soluzione di VisionRT

Sistema completo, prodotto da VisonRT, azienda leader mondiale nel mercato della *Surface Guided Radiation Therapy* (**SGRT**), basato su tre (3) telecamere 3D ad alta definizione (HD) in grado di

- ricostruire con estrema accuratezza **(<1 mm in traslazione, <1° in rotazione**) la superficie esterna 3D del paziente, e
- farne il *tracking* in tempo reale, durante l'erogazione del trattamento stesso, senza l'impiego di radiazioni ionizzanti

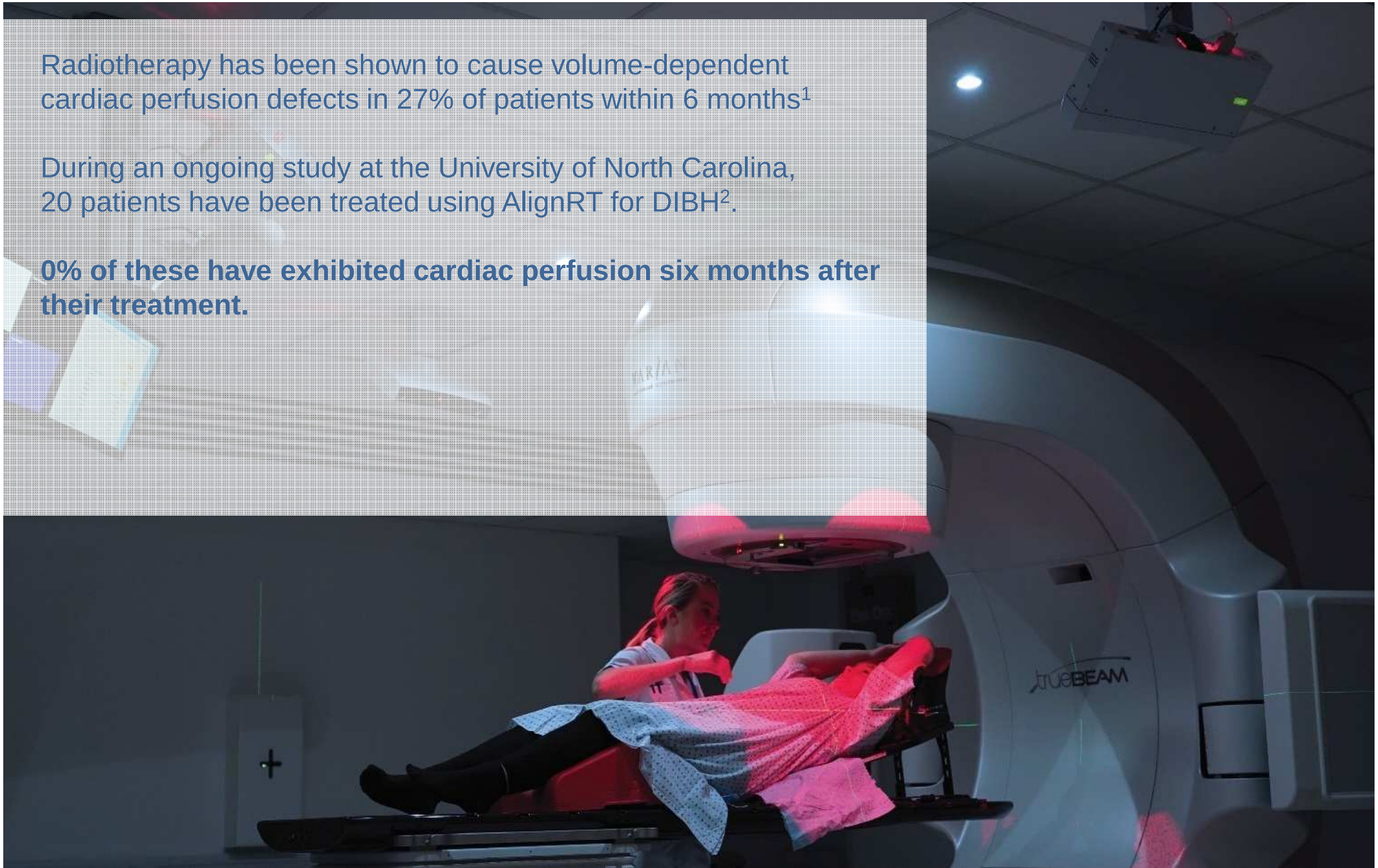


AlignRT: impatto clinico

Radiotherapy has been shown to cause volume-dependent cardiac perfusion defects in 27% of patients within 6 months[1]

During an ongoing study at the University of North Carolina, 20 patients have been treated using AlignRT for DIBH[2].

0% of these have exhibited cardiac perfusion six months after their treatment.



AlignRT: trasversalità di applicazione

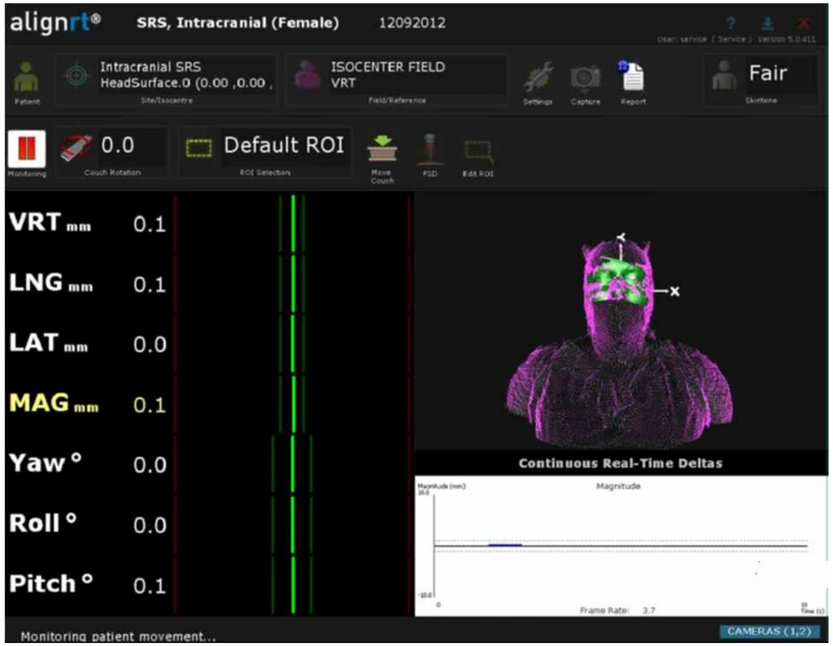
AlignRT è gestito da un software con interfaccia utente estremamente intuitiva e può essere impiegato per tutte le tipologie di trattamento, risultando particolarmente efficace

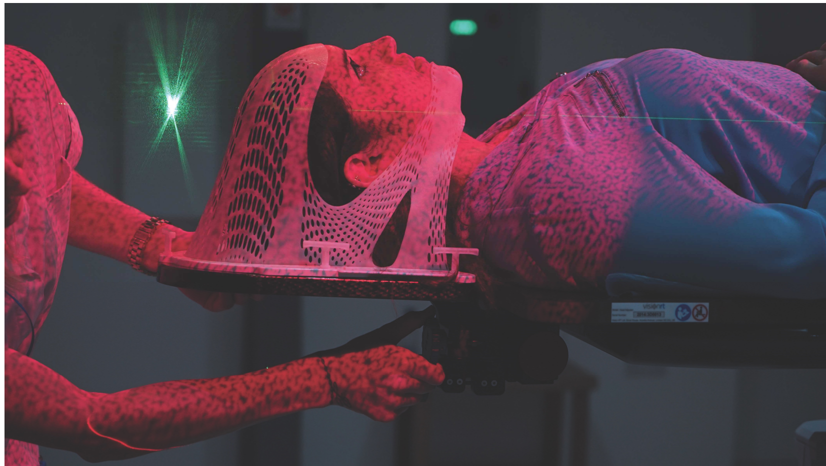
- nelle tecniche di breath-hold, e/o
- per tutte le tecniche con ipofrazionamento, poiché in grado di garandire elevata riproducibilità e ridurre al minimo gli errori di localizzazione

AlignRT: frameless SRS

Una delle caratteristiche esclusive del sistema VisonRT AlignRT è la possibilità di definire regioni anatomiche di interesse (ROI), da cui seguono infatti i seguenti **Vantaggi**:

- possibilità "confinare" il *tracking* alle sole regioni che coinvolgono la corretta localizzazione del target ignorando tutte le restanti: per questo, a differenza di altri sistemi in commercio, la tecnologia VisionRT consente di effettuare SGRT con tracking basato su algoritmi di **registrazione rigida**
- possibilità di aumentare sensibilmente la velocità di risposta complessiva del sistema. Come facilmente intuibile, al diminuire (mediante le opportune ROI mirate) dell'area da monitorare, diminuisce il "lavoro" da svolgere del sistema, per questo, anche tempo di risposta. Ciò è fondamentale nell'ottica del **risparmio di dose impropria a strutture a rischio** (OAR)





Grazie per l'attenzione

Davide Raspanti, Ing., Senior Product Specialist