ISSN 2282-5746

Fisica in Medicina

Periodico trimestrale di formazione, informazione e aggiornamento dell' Associazione Italiana di Fisica Medica

STEREOTACTIC BODY RADIATION THERAPY

Implementazione, Sostenibilità, Avanzamento Tecnologico e Risultati a Confronto

Numero Monografico

aifm
ASSOCIAZIONE ITALIANA DI FISICA MEDICA

n. 2 - 2015

Fisica in Medicina

n. 2/2015
Luglio-Agosto-Settembre

Periodico Trimestrale di formazione
Informazione e aggiornamento de lla
Associazione Italiana di Fisica Medica

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Sommario:

Periodico
Fisica in Medicina

Trimestrale dell'Associazione Italiana di Fisica Medica, Piazza della Repubblica 32, 20124 Milano – Autorizzazione n. 403 del 20/12/2013 Tribunale di Milano

Pubblicato nel mese di Luglio 2015

In copertina: Convegni e congressi: "Stereotactic Body Radiation Therapy" - Milano 2014; Concept grafico di Alice Allevi

Alla realizzazione di questo numero hanno partecipato: Trancesca Romana Giglioli ed Elena Villaggi.'

Introduzione

P. Mancosu

Questo numero della nostra rivista è dedicato agli atti del convegno organizzato da AIFM e patrocinato da AIRO, "SBRT: implementazione, sostenibilità, avanzamento tecnologico e risultati a confronto" svoltosi lo scorso 24-25 Ottobre 2015 presso l'aula magna della facoltà di Scienze della Università degli Studi di Milano.

"La radioterapia moderna evolve sempre di più verso una riduzione del numero di sedute di trattamento. In particolare, la stereotactic body radiotherapy (SBRT), o come più recentemente chiamata, SABR (stereotactic ablative radiotherapy) sta diventando terapia di elezione, per pazienti selezionati, in diversi distretti anatomici, sia per tumori primitivi che per lesioni metastatiche. Nel solo 2013, ben 1277 pubblicazioni indicizzate su PubMed riguardano questa metodica. L'irradiazione ad alte dosi per frazione (>7Gy/seduta) ad un volume tumorale ridotto, peculiarità della SBRT/SABR, è da considerarsi come tecnica complessa che richiede un'analisi approfondita di tutti gli aspetti che concorrono al risultato del trattamento. Per tale motivo nel 2012 l'AIFM ha costituito un Gruppo di Lavoro specifico dal titolo: "Aspetti fisico dosimetrici e radiobiologici della radioterapia ablativa ipofrazionata ad alte dosi guidata dalle immagini" al quale partecipano più di 100 fisici medici italiani.

L'obiettivo di questo convegno è fornire una panoramica attuale sulla metodica, evidenziare quanto approfondito all'interno del gruppo di lavoro e condividere gli aspetti tecnico/scientifici e clinici con Medici Radioterapisti Oncologi, Fisici Medici, e tutte le figure tecnico/scientifiche coinvolte."

Con questi obiettivi il comitato scientifico, composto da Filippo Alongi, Marie Claire Cantone, Francesca Romana Giglioli, Michele Stasi e Lidia Strigari, ha invitato alcuni tra i migliori specialisti del campo a confrontarsi sullo stato dell'arte della SBRT moderna.
Il convegno ha richiamato più di 200 colleghi fisici medici e oncologi radioterapisti da tutta Italia. Segno della vitalità e interesse sull'argomento sono stati i 40 e più abstract di carattere fisico e clinico selezionati da un comitato di esperti (Alongi, Corvò, Maurizi Enrici per i medici e Begnozzi, Bucciolini, Cantone, Iori per i fisici).

Il volume include l'intervento del nostro presidente, Luisa Begnozzi, su IlSole24Ore riguardante il convegno, gli abstacts selezionati e le interviste fatte da Francesca Romana Giglioli ai quattro vincitori dei premi per i migliori contributi, per mostrare che dietro alle presentazioni scientifiche ci sono persone con le proprie storie e i propri interessi.

Pietro Mancosu

Per il comitato organizzatore del convegno

Figura 1: Presentazione del convegno da parte dei presidenti AIFM ed AIRO, Luisa Begnozzi e prof. Riccardo Maurizi Enrici.

Figura 2: Più di 200 colleghi giovani e meno giovani attenti agli interventi del convegno.

Figura 3: Vista dell'aula magna durante le presentazioni orali dei giovani colleghi fisici e medici.

UNIVERSITÀ DEGLI STUDI DI MILANO

Aifm

24/25 OTTOBRE 2014

Università degli studi di Milano

STEREOTACTIC BODY RADIATION THERAPY

Implementazione, Sostenibilità, Avanzamento Tecnologico e Risultati a Confronto

Con il patrocinio di:

RAO Associazione Italiana Radioterapia Oncologica

Obiettivo ECM: "Innovazione tecnologica: valutazione, miglioramento dei processi di gestione delle tecnologie biomediche e dei dispositivi medici. Health Technology Assessment."
Evento ECM: n° 416/____

Aifm

7,5 Crediti ECM per la figura professionale di Fisica medica, Medico Radioterapista

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Marie Claire Cantone
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Segreteria Organizzativa:

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Tel. 06 5818895; Fax 06 5818308
e-mail: **segreteria@fondazionefatebenefratelli.it**
sito internet: **www.fondazionefatebenefratelli.it**

FINALITA' DEL CONVEGNO

La radioterapia moderna evolve sempre di più verso una riduzione del numero di sedute di trattamento. In particolare, la stereotactic body radiotherapy (SBRT), o come più recentemente chiamata, SABR (stereotactic ablative radiotherapy) sta diventando terapia di elezione, per pazienti selezionati, in diversi distretti anatomici, sia per tumori primitivi che per lesioni metastatiche.
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Si ringrazia:

abmedica · BRAINLAB · DosimET · ELEKTA · ELSE · TA TECNOLOGIE AVANZATE · Tema SINERGIE · VARIAN medical systems

Sede del Convegno:

Università degli Studi di Milano
Via Luigi Mangiagalli 25 (Aula Magna),
Milano (MM2 Piola)

Quota di partecipazione:

Soci AIFM/AIRO: € 100,00
Specializzandi AIFM/AIRO: € 50,00
non soci: € 200,00
(include il pagamento dell'imposta di bollo)
La quota comprende: iscrizione al corso, n°2 coffee break, n°1 pranzo e materiale didattico in formato elettronico.

Modalità di iscrizione:

La sala ha una capienza di **250 posti**. Il corso è accreditato per Fisici Medici, Medici Radioterapisti.
Sarà possibile effettuare l'iscrizione alla voce Corsi AIFM-FIF sul sito

www.fondazionefatebenefratelli.it/formazione

Si considera conferma dell'iscrizione l'avvenuto pagamento della quota. In caso di annullamento del corso la quota di iscrizione sarà rimborsata. Nel caso di recesso di un iscritto la quota sarà rimborsata solo se tale comunicazione (via fax o mail) sarà inviata alla segreteria prima dell'inizio del corso.

Non sarà possibile pagare la quota in sede di Corso.

Abstract:

Sono previste due sezioni per comunicazioni orali e poster di carattere fisico e clinico.
In particolare le migliori **quattro comunicazioni di giovani** (due fisiche e due cliniche) Under 32 o Specializzandi saranno **premiate con 1000 euro e 250 euro**.
Gli abstract dovranno essere in lingua inglese ed inviati alla mail **SBRT@fisicamedica.org entro Lunedì 15 Settembre 2014**.

Gli abstract dovranno includere i nomi degli autori con enti di appartenenza, specificando il nome del presentatore, la preferenza tra comunicazione orale e poster, la sezione di pertinenza (fisico o clinico) e l'eventuale candidatura ai premi. Gli abstract dovranno essere divisi nelle sezioni: Introduction; Materials&Methods; Results; Conclusion. Il limite di caratteri è fissato a 2500, spazi inclusi. L'abstract potrà contenere una figura/tabella.
Tutto il materiale didattico sarà pubblicato online sul sito www.aifm.it

PROGRAMMA

Venerdì 24 Ottobre 2014

13.30 Registrazione partecipanti

14:00 Presentazione del corso
L. Begnozzi (Presidente AIFM)
R. Maurizi Enrici (Presidente AIRO)

14:30 Lezione magistrale
Approccio multidisciplinare in Radioterapia
V. Valentini (già Presidente ESTRO)

15:00 Lezione magistrale
Prospettive della SBRT tra evidenze e rischi
C. Fiorino, Ospedale San Raffaele, Milano

15:30 Coffee Break

Sessione I (Chair: F. Giglioli, M. Stasi)

16:00 Radiobiologia: High dose per fraction
L. Strigari (IFO. Roma)

16:30 Fisica dei campi piccoli
S. Russo (ASF, Firenze)

17:00 Applicazione clinica: Prostata
S. Arcangeli (S.Camillo-Forlanini, Roma)

17:30 Comunicazioni libere

18:00 Poster

18:30 Chiusura lavori

Sabato 25 Ottobre 2014

Sessione II (Chair: F. Alongi, M. Cantone)

8:30 Lezione magistrale
Visione e sostenibilità della sanità italiana
F. Fazio (già Ministro Salute Italiano)

9:00 Image Guided RT in SBRT
C. Fiandra (Università degli Studi di Torino)

9:30 Applicazione clinica: Polmone
U. Ricardi (Università degli Studi di Torino)

10:00 Rischio clinico in SBRT
I. Veronese (Università degli Studi di Milano)

10:30 Coffee Break

Sessione III (Chair: M. Bucciolini, R. Corvò)

11:00 Imaging in SBRT: aspetti tecnico/dosimetrici correlati S.Clemente (CROB, Rionero in Vulture)

11:30 Applicazione clinica: Fegato
M. Scorsetti (Humanitas, Milano)

12:00 Comunicazioni libere

13:00 Pranzo

14:00 Sviluppo tecnologico delle aziende in SBRT

Sessione IV (Chair: L. Begnozzi, R. Maurizi Enrici)

15:00 Controlli di qualità in SBRT
C. Marino (Humanitas, Catania)

15:30 Applicazione clinica: Ritrattamenti
B. Jereczec-Fossa (IEO, Milano)

16:00 Esperienza multiplanning del GdL SBRT
M. Esposito (ASF, Firenze)

16:30 Discussione e premiazione

17:00 Compilazione questionari

17:30 Chiusura lavori

Il servizio catering sarà svolto da: Operazione Mato Grosso che devolverà una parte del ricavato alle attività svolte in Brasile

Interviste ai vincitori

Ciro Franzese (Medico)

Quale è stato il tuo percorso scolastico?

Il mio percorso formativo ha avuto inizio a Napoli, la mia città natale, dove mi sono laureato in Medicina e Chirurgia e abilitato alla professione nel 2008. Nel 2009, con tanta emozione e un po' di ansia ho lasciato la casa dei miei genitori per andare a vivere a Firenze dove ho superato il concorso in Radioterapia. Nell'Ospedale Careggi ho trascorso 5 anni molto duri, molto intensi, molto formativi. Ho imparato tecniche radioterapiche classiche, come la 3DCRT, e modalità di trattamento più moderne, come IMRT e IGRT. Durante gli anni di specializzazione ho trascorso un anno a Londra, al Royal Marsden Hospital, dove oltre ad approfondire l'oncologia del distretto testa-collo e polmonare con tutor eccelsi quali il Prof. Harrington ed il prof. Nutting, ho cercato di fare mia l'idea di internazionalità che può caratterizzare il lavoro del medico.

cosa fai in questo momento?

Dal 2014, terminata la specializzazione, ho cominciato un rapporto di libera professione con l'Istituto Humanitas di Rozzano (MI). Mi occupo della patologica cervico-cefalica, genito-urinaria e del distretto epato-pancreatico. Qui ho la possibilità di esprimermi al meglio in un ambiente giovane,collaborante, dove ho la sensazione che venga premiata la meritocrazia. Da Napoli a Milano non è stato semplice, due stili di vita e lavorativi molto complessi e diversi l'uno d'altro. Ma sono convinto che se tornassi indietro farei le stesse scelte, una ad una.

come vedi il futuro prossimo?

Il mio futuro per il momento lo vedo qui dove sono. Famiglia ed amici sono lontani, il sacrificio non è di poco conto, ma credo di essere al posto giusto nel momento giusto. Ho tutti i mezzi per crescere dal punto di vista umano e professionale. Sento di star investendo in me stesso e che con tanta pazienza ed ambizione riuscirò negli obiettivi che mi sono prefissato. Per il momento mi sento fortunato perché faccio un lavoro che mi piace, perché ho un cane di 40 Kg che riempie il mio tempo libero e perché Milan l'è un gran Milano (ok, questa non è mia ovviamente, cit.)

qual è l'aspetto più attraente della professione che eserciti o cui aspiri?

Cosa mi attrae del mio lavoro? La continua evoluzione di una componente tecnologica che corre ad una velocità sfrenata. Non sai cosa succederà domani, non puoi immaginare come le nuove scoperte

cambieranno il tuo modo di lavorare e questo rende tutto il tuo lavoro particolarmente affascinante. E poi i pazienti, la loro soddisfazione, nel ricevere trattamenti sempre più efficaci e sempre meno tossici.

Elisabetta Ponti (Medico)

Quale è stato il tuo percorso scolastico

Ho cominciato a frequentare, da studente, il reparto di Radioterapia dell' Università di Roma Tor Vergata diretta dal Prof. Riccardo Santoni nel 2005. Mi sono laureata in Medicina e Chirurgia nel 2008 e l'oggetto della mia tesi è stato il seguente: "Valutazione della tossicità rettale in pazienti trattati con radioterapia radicale per tumore della prostata". Nel 2009 sono entrata in Specializzazione in Radioterapia e durante questi anni ho avuto l'opportunità di crescere in questo lavoro e di partecipare alle diverse attività dei vari gruppi di lavoro all'interno del reparto, con maggiore interesse alle patologie uro-genitali ed al tumore della prostata in particolare, settore oggetto di diversi studi scientifici a cui ho contribuito.

Ho avuto anche l'opportunità di fare un' esperienza all'estero come Clinical Observer presso il Christie Hospital di Manchester. In tale periodo ho partecipato attivamente all'attività clinica, ai Journal Club, meeting multidisciplinari...esperienza che mi ha permesso di mettermi in discussione confrontandomi con una realtà lavorativa diversa.

cosa fai in questo momento?

Ho discusso la tesi la specializzazione due mesi fa sul seguente argomento "Radioterapia image guided nel tumore localizzato della prostata mediante cone beam CT e impianto di fiducial markers intraprostatici: valutazione off - line dello spostamento inter – frazione del clinical target volume". In questo momento di transizione sto nel frattempo effettuando un'attività lavorativa che mi permette di guadagnare ma che al tempo stesso mi consente di continuare a frequentare il reparto di Radioterapia di Tor Vergata per continuare a portare avanti delle importanti collaborazioni scientifiche perchè la mia ambizione principale e' quella di poter lavorare nell'ambito della disciplina della mia Specializzazione.

come vedi il futuro prossimo?

Come ho già detto la mia ambizione principale è quella di poter lavorare come Oncologo Radioterapista. So che non è un momento facile dal punto di vista lavorativo per la sanità del Lazio e di altre regioni ma non mi voglio scoraggiare e dare per vinta perseverando nel mio obiettivo e non escludo, se possa esserci la possibilità, di poter effettuare attività lavorative altrove o all'estero. Nel prossimo mese effettuerò il Concorso per il Dottorato presso il Dipartimento del mio campo di interesse della mia Università di appartenenza per eventualmente continuare ad approfondire la

ricerca scientifica: so che i posti sono limitati e tanti gli aspiranti, ma non mi voglio precludere questa eventuale possibilità.

qual è l'aspetto più attraente della professione che eserciti o cui aspiri?

Ciò che mi affascina di più di questa professione è la continua dinamicità di questo lavoro per il continuo evolversi della tecnologia e la possibilità di potermi mettere sempre in discussione confrontandomi con realtà diverse.

Nicola Maffei (Fisico)

Quale è stato il tuo percorso scolastico?

Ho conseguito nell'A.A. 2010/2011 la Laurea Triennale in Fisica presso l'Università degli Studi di Bari – Facoltà di Scienze Matematiche Fisiche e Naturali. Prediligendo un indirizzo di studi più applicativo, per il lavoro di tesi mi sono occupato di: "Produzione di idrogeno da FER, stoccaggio e utilizzo: stato dell'arte".

http://beta.fisica.uniba.it/Portals/1/Archivio_tesi/triennale/Maffei_tri.pdf

Nell'A.A. 2012/2013 ho conseguito la Laurea Magistrale in Fisica Applicata presso l'Alma Mater Studiorum Università di Bologna - Facoltà di Scienze Matematiche Fisiche e Naturali. In questi due anni mi sono avvicinato, inizialmente per curiosità, al campo della Fisica Medica per poi terminare il percorso di studi con una tesi sperimentale in radioterapia oncologica: "Reti neurali e modelli fisico-predittivi: dati clinici e analisi di trattamenti in Tomotherapy".

http://amslaurea.unibo.it/6621/1/maffei_nicola_tesi.pdf

cosa fai in questo momento?

Dallo scorso anno sono titolare di una borsa di studio ai fini della ricerca scientifica dal titolo: "Sviluppo dose accumulation e reti neurali per adaptive radioterapia" presso l'Azienda Ospedaliero – Universitaria di Modena, Policlinico.

Nell'ambito del Progetto di ricerca del Ministero della Salute (GR-2010-2318757) dal titolo: "Dose warping methods for IGRT and Adaptive RT: dose accumulation based on organ motion and anatomical variations of the patients during radiation therapy treatments", le mie principali attività di ricerca sono:

- Implementazione di predictive Neural Network per applicazioni clinico-fisiche;
- Utilizzo di Treatment Planning System per simulazioni e analisi retrospettiva di trattamenti radioterapici;
- Raccolta dati, analisi statistica e creazione di large DB per la gestione di file DICOMRT;
- Sviluppo di script per l'automatizzazione di processi di Adaptive Radiation Therapy;
- Progettazione, realizzazione e programmazione di fantocci antropomorfi dinamici per la sperimentazione in campo bio-meccanico;
- Controlli dosimetrici e Patient Quality Assurance;
- Studio e simulazione di modelli epidemiologici innovativi per applicazioni oncologiche;
- Progetto di componentistica bio-medicale mediante stampa 3D;
- Letteratura scientifica.

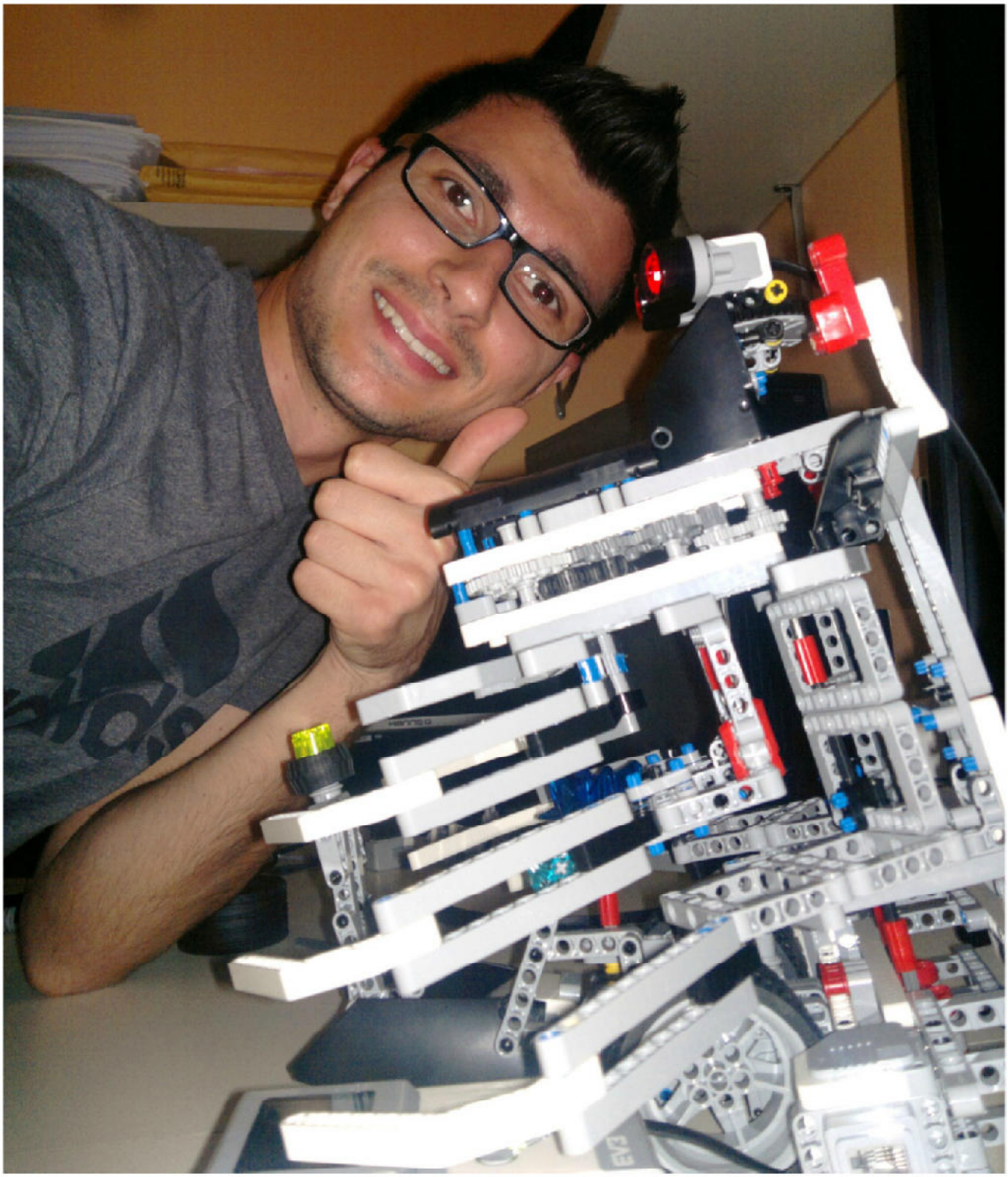
Questo è il nostro sito dove poter seguire le attività di ricerca:
http://medicalphysicsresearch.weebly.com/

come vedi il futuro prossimo?

Riuscire a scorgere in questo momento un futuro chiaro è forse il limite più grande che rallenta la maggior parte dei giovani laureati. Sono convinto della validità e qualità dell'istruzione universitaria del mio Paese e personalmente ritengo che le nuove menti italiane possano fornire un supporto concreto allo sviluppo scientifico e culturale sia nazionale che internazionale. Coraggio e intraprendenza in generale non mancano ma credo che per arrivare lontano, resti imprescindibile un atto di lungimirante fiducia da parte delle istituzioni. Scommettere sulle future generazioni invece che giocare al ribasso penso sia l'unica via logica da perseguire per evitare il brain drain.

qual è l'aspetto più attraente della professione che eserciti o cui aspiri?

Credo che nel bene o nel male l'evoluzione umana sia in generale qualcosa d'inarrestabile. È nostro compito però finalizzare il progresso ad un benessere globale. Fare ricerca è secondo me il modo che permette effettivamente di essere "nani sulle spalle dei giganti" e, mattoncino su mattoncino (ovviamente LEGO), portare la conoscenza umana a un livello sempre maggiore.
Occuparsi di ricerca in Fisica Medica è poi qualcosa di davvero emozionante e gratificante. Sapere che il tuo studio e le ore di lavoro sono in qualche modo legate al benessere di un altro essere umano è probabilmente la marcia in più che caratterizza questa categoria di fisici.
Pensare al futuro come un qualcosa da plasmare e costruire sulla base delle proprie visioni credo sia una delle ragioni più nobili del continuare a cercare …



Tommaso Giandini (Fisico)

Quale è stato il tuo percorso scolastico?

Ho frequentato il liceo classico Melchiorre Gioia a Piacenza, mia città di origine. In realtà si trattava di una nuova sperimentazione scientifica appena avviata, in altri termini un liceo scientifico nella sede del classico: scommessa vinta ed esperienza molto positiva. Mi sono poi trasferito a Pavia per frequentare la laura triennale in fisica presso quell'ateneo, altra ottima esperienza scolastica e di vita. Sempre con base a Pavia ho frequentato la laurea magistrale presso l'Università degli Studi di Milano, indirizzo Fisica Sanitaria: è qui che ho scoperto l'affascinante mondo della fisica medica. Svolgendo la tesi presso la Fondazione IRCCS Istituto Nazionale dei Tumori di Milano, alla corte dei dottori Giancarlo Zonca ed Emanuele Pignoli, ho avuto modo di vivere in prima persona il lavoro del fisico medico e la passione per questa disciplina è ulteriormente cresciuta. Frequentando poi la Scuola di Specializzazione di Milano e grazie al tirocinio all'Istituto dei Tumori ho potuto approfondire la conoscenza dei diversi ambiti della fisica medica. Il 29 maggio 2014 ho finalmente ottenuto la specializzazione in fisica medica.

cosa fai in questo momento?

Sono attualmente un borsista dell'Istituto Europeo di Oncologia (IEO) di Milano su un progetto di ricerca AIRC dal titolo "Carbon ions boost followed by pelvic photon intensity modulated radiotherapy for high risk prostate cancer". Questo progetto coinvolge IEO, il Centro Nazionale di Adroterapia Oncologica di Pavia (CNAO) e l'Istituto Nazionale dei Tumori, dove svolgo interamente la mia attività di ricerca e continuo la mia crescita professionale e umana.

come vedi il futuro prossimo?

Inanzitutto a settembre mi vedo sposato, a meno che la mia dolce metà nel frattempo non ci ripensi…Per quanto riguarda il lavoro ho ancora due anni di progetto di ricerca davanti, dopodiché si vedrà. La situazione in Lombardia (e non solo) è sempre più complicata, nel senso che ogni anno aumenta il numero degli specializzati ma l'offerta di lavoro negli ospedali è ridotta al lumicino. Succede così che diversi ragazzi molto preparati e con tanta voglia di lavorare rimangano a spasso o si trovino costretti ad accettare lavori ben lontani dalla professionalità tanto faticosamente raggiunta. Questo dovrebbe far pensare un po' tutti …

qual è l'aspetto più attraente della professione che eserciti o cui aspiri?

Un aspetto di questo lavoro che trovo molto attraente è il lavoro in team, in particolare la multidisciplinarietà, cioè collaborare con figure professionali diverse (ad esempio radioterapisti e tecnici di radiologia), ognuna caratterizzata da competenze, attitudini e linguaggi diversi. In questo contesto penso sia importante saper interagire e confrontarsi nel modo giusto per ottenere insieme ottimi risultati.Un altro aspetto attraente è la possibilità di lavorare (e "giocare") con strumenti all'avanguardia e in continua evoluzione, che spingono il fisico medico a restare sempre aggiornato e forniscono spunti per nuove ricerche.Infine, l'aspetto più importante e gratificante di tutti è sapere che nel tuo piccolo, col "videogame" con cui pianifichi i trattamenti radioterapici, con la tua strumentazione da nerd per i controlli di qualità dei macchinari e con la tua predisposizione quasi paranoica ad effettuare n-mila misure, contribuisci ad aiutare, e spesso salvare, sempre più malati.

La radioterapia moderna ed il ruolo sempre più rilevante del fisico medico

Di Luisa Begnozzi, presidente AIFM
16 Gennaio 2015
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La tecnologia in medicina diventa un elemento sempre più importante nella cura di patologie complesse come le patologie tumorali. In questo, la radioterapia rappresenta un ottimo esempio di multidisciplinarietà, collaborazione e complementarietà di figure professionali differenti: alle competenze cliniche dello specialista radioterapista oncologo è associato il ruolo del fisico medico.

La radioterapia moderna evolve sempre di più verso una riduzione del numero di sedute di trattamento. La stereotactic body radiotherapy (SBRT) o, come più recentemente chiamata, SABR (stereotactic ablative radiotherapy) negli ultimi anni sta diventando terapia di elezione, per pazienti selezionati, in diversi distretti anatomici, sia per tumori primitivi che per lesioni metastatiche. La SBRT utilizza fasci di radiazioni concentrate in dosi elevate per distruggere i tumori in aree difficili da raggiungere. Il trattamento non è invasivo e riduce al minimo i danni ai tessuti sani circostanti.

Su questo tema si sono confrontati più di 200 specialisti fisici e medici radioterapisti presso l'Università degli Studi di Milano nel corso del convegno "SBRT: implementazione, sostenibilità, avanzamento tecnologico, e risultati a confronto".

L'irradiazione ad alte dosi per frazione (>7Gy/seduta) a un volume tumorale ridotto (anche pochi cc), peculiarità della SBRT/SABR, è da considerarsi come tecnica complessa che richiede un'analisi approfondita di tutti gli aspetti che concorrono al risultato del trattamento. Infatti, il volume ridotto da irradiare e la prossimità con organi a rischio circostanti richiedono di mantenere una precisione sub-millimetrica per tutto il trattamento. La fusione di immagini multimodali (PET, TAC, risonanza magnetica), lo studio della dosimetria per campi di radiazione piccoli, l'esecuzione dei controlli di qualità prima dell'erogazione del trattamento sul paziente, la verifica dell'accuratezza dell'isocentro durante l'irradiazione, l'imaging durante terapia (il cosiddetto IGRT – image guided radiotherapy)

sono solo alcuni degli aspetti nei quali i fisici medici intervengono per fornire la sicurezza al radioterapista oncologo di colpire il tumore in maniera corretta.

Come detto è di fondamentale importanza l'accuratezza dosimetrica dato che si è in presenza di alte dosi e campi di radiazione piccoli per i quali è necessario andare oltre i protocolli standard di misura della dose assoluta. Proprio per questo è necessario utilizzare adeguati e specifici sistemi di misura della dose. Aspetti questi che coinvolgono la competenza e responsabilità del fisico medico. Ricordiamo che anche la nuova direttiva europea di radioprotezione 59/2013 in fase di recepimento da parte degli stati membri che al capo VII tratta delle applicazioni delle radiazioni in campo medico, stressa molto tale responsabilità, definendo il fisico specialista in fisica medica come il responsabile della dosimetria all'art. 83.

Per affrontare le molte tematiche di carattere fisico dosimetrico, nel 2012 l'Aifm (Associazione Italiana di Fisica Medica) ha costituito un Gruppo di Lavoro specifico dal titolo: «Aspetti fisico dosimetrici e radiobiologici della radioterapia ablativa ipofrazionata ad alte dosi guidata dalle immagini» al quale, a oggi, partecipano più di 100 fisici medici italiani. Diversi studi multicentrici sono stati compiuti a riguardo dei vari aspetti di questa tecnica coinvolgendo decine di centri italiani tra nord e sud e i risultati sono in fase di pubblicazione sulle più prestigiose riviste internazionali di settore. Questo sta permettendo il miglioramento degli aspetti dosimetrici di questa tecnica. Tra gli obiettivi del gruppo di lavoro c'è la stesura di un documento di linee guida da condividere con Airo (Associazione Italiana Radioterapia Oncologica) nel quale siano chiarite e standardizzate le procedure dosimetriche riguardanti la Sbrt.

Abstract Medici Selezionati

VERO/MITSUBISHI BRAIN Lab RADIOTHERAPY: Case profile, feasibility and acute toxicity in consecutive 789 patients/957 lesions

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Introduction

VERO-radiotherapy (VERO-RT) was implemented in our department in 4/2012 and it was one of the first installations of this unique precise radiotherapy system over the world. The aim of this retrospective study is to evaluate patient profile, feasibility and acute toxicity of VERO-RT in the first 20 months of clinical activity.

Methods

Inclusion criteria: 1) adult patients; 2) limited volume cancer (M0 or oligometastatic); 3) VERO-RT between 4/2012 and 12/2013 and 5) written informed consent. Two techniques were employed: intensity modulated radiotherapy (IMRT) and stereotactic body radiotherapy (SBRT). Toxicity was evaluated using Radiation Therapy Oncology Group/European Organization for Research and Treatment of Cancer (RTOG/EORTC) and Common Terminology Criteria for Adverse Events (CTCAE) criteria.

Results

Between 4/2012 and 12/2013, 789 consecutive patients were treated (957 lesions): in 84% 1 lesion was treated, in 16% more than 1 lesion was treated synchronously/metachronously. Median age was 70y (20-91)male/female 541 (69%)/248 (31%). First radiotherapy in 85% , re-irradiation in 13% and boost in 2% of cases. Primary diagnosis included urology (354 patients, 45%), lung (176 patients, 22%), gastrointestinal (94 patients, 12%), breast (72 patients, 9%), gynecological (60 patients, 8%), head/neck (8 patients, 1%) and other malignancies (25 patients, 3%). The treated region included neck (13 lesions, 1%), thorax (363 lesions, 38%), upper abdomen (140 lesions,

15%), pelvis (441 lesions, 46%). T, N and M lesions were treated in 476 (50%), 139 (14%) and 342 (36%) patients, respectively. M category included bone, nodal and visceral metastases. VERO-RT schedules included < 5 and > 5 fractions (extreme and moderate hypofractionation) in 75% and 25%, respectively.All patients completed planned VERO-RT and only 2 cases of G4 acute toxicity was observed.

Conclusions

VERO-RT was administrated predominantly to pelvic and thoracic lesions (lung and urologic tumors) using hypofractionation. It is a feasible approach for limited burden cancer offering short and well accepted treatment with low acute toxicity profile. Further investigation including dose escalation and other available VERO-RT functions (tumor tracking) is warranted in order to fully evaluate this innovative radiotherapy system.

Stereotactic Ablative Radiotherapy as first local therapy for lung oligometastases from colorectal cancer: a single-institution cohort study.

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Introduction

Clinical data are lacking on Stereotactic Ablative Radiotherapy (SABR) for lung metastases from colo-rectal cancer (CRC). The study was designed with the primary aim of estimating SABR efficacy and its potential role as an alternative to surgery in this setting.

Materials and Methods

Forty consecutive patients who received SABR as first local therapy at the time of lung progression were included, from 2005 to 2013. Primary study endpoint was overall survival (OS). Secondary endpoints were progression-free survival (PFS) and safety.

Results

A single nodule was treated in 26 patients (65%), 2 nodules in 10 patients (25%), 3 in 3 patients (7.5%) and 4 in 1 patient (2.5%), for a total of 59 lesions. The median delivered biological effective dose was 96 Gy, in 1 to 8 daily fractions. Median follow up time was 20 months (range 3-72). OS rates at 1, 2 and 5 years were respectively 84%, 73% and 39%, with 14 patients (35%) dead. Median OS was 46 months. Progression occurred in 25 patients (62.5%), at a median interval of 8 months; failure at SABR site was observed in 3 patients (7.5%). Progression-Free Survival rates were 49%, 27% at 1 and 2 years, respectively.

Conclusion

Results of this retrospective exploratory analysis provide initial evidence supporting the efficacy and safety of SABR in patients affected with CRC lung oligometastases and suggest the inclusion of SABR in prospective clinical trials.

Vincitore SBRT 2014: Stereotactic body radiation therapy in oligometastatic patient with lymph node recurrent prostate cancer: a single centre experience

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Introduction

The aim of the present study was toevaluate the efficacy of stereotactic body radiation therapy (SBRT) as a treatment modality in 16 oligometastatic prostate cancer patientsin terms of Local Control (LC), Progression free-survival (PFS), Overall Survival (OS) and toxicity.

Materials and methods

Sixteen patients with 18 isolated lymph node recurrent prostate cancer were treated at our Department between 2008 and 2013. All patients underwent [^{11}C] choline-positron emission tomography/computed tomography ([^{11}C]CPET/CT) to exclude other sites of disease. Two patients were treated in different sessions for metachronous metastases. Ten patients received androgen deprivation therapy (ADT) concomitant to SBRT. A total dose ranged between 12 to 35 Gy, delivered from 1 to 5 fractions.

Results

All patients completed the prescribed radiation treatment, with no interruption. One patient reported G2 acute gastrointestinal (GI) toxicity and late toxicity was observed in only one patient who had G3 GI toxicity. Mean and median follow-up periods were 29.35 and 29.38 months respectively (range between 6.3-68.8 months). Mean and median serum PSA post-SBRT values were of 2.85 and 2.60 respectively (range between 0.01-8.9 ng/ml). The local disease control and decrease in serum PSA were obtained in 15 out 16 (94%) patients. Only one patient had progression in field. At last follow up 8 patients had active prostate cancer disease; clinical progression was observed after a mean time of 17.9 months from the completion of SBRT.The pattern of recurrence was as follows: 4 patients with lymph node recurrence all outside the irradiated area, 2 patients were oligometastatic to bone, 2 patients to bone and lymph nodes and 1 patients presented a systemic spread to bone and liver. Seven patients had no evidence disease. One patients died of disease. Overall survival was 94% . In the six patients without hormone therapy at the time of SBRT the

mean time of deferment of palliative ADT was 23.7 months (range between 2,5-51 months). The 2 years biochemical relapse free survival (b-RFS) was 44%.

Conclusion

In conclusion our experience confirm that the use of SBRT has been proven to be safe, effective and minimally invasive in the eradication of limited nodal recurrence from oligometastatic prostate cancer. SBRT is well tolerated by patients with low toxicity and yielded a local control of the disease.

Breath training increases the proportion of lung cancer patients fit for 4DCT simulation before Stereotactic Ablative Radiotherapy.

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Introduction

Four-dimensions computed tomography (4D CT) is routinely usedfor target volume delineation for lung SABR. In daily practice, a consistent proportion of patients (up to 40%) may be excluded due to an irregular breath cycle and/or breath rate range.Information obtained from 4DCT are consistent if patient breath cycle is regular, in order to minimize movement artefacts , so we have to take into account some parameters, like amplitude standard deviation (≤ 0.22) and breath rate range.The aim of this work was to evaluate if respiratory training before 4DCT would increase the rate of lung cancer patients eligible to 4DCT.

Materials and Methods

An Elekta ABC system was used to help patients in visualizing their breath cycle on a monitor connected to a spirometer; patients were then asked to perform two or three training sessions at our Department and to perform training at home, before planning CT acquisition. This training was aimed to check their breath rate and then try to maintain it constant over time. Thirty-two patients were selected for this study, and 4DCT were collected (maximum and minimum breath rate, amplitude variance); a control group of 50 patients who underwent 4DCT without previous training was then selected for comparison. Statistical analysis included analysis of amplitude variance by Fisher test and breath rate by t-Student test.

Results

No significant differences were detected in the interval between maximum and minimum breath between the two patients group (t-Student $p=0.75$). Conversely, a significantly higher proportion of patients in the training group had an acceptable amplitude variance (Fisher test $p=0.03$, Figure 1).

Conclusion

These preliminary data show a breath training protocol may be useful in limiting respiratory movements and increasing the proportion of lung cancer patients eligible for 4DCT prior to SABR.

The challenge of inoperable Hepatocellular Carcinoma (HCC): results of a single-institutional experience on Stereotactic Body Radiation Therapy (SBRT)

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Objectives

To evaluate the feasibility and efficacy of SBRT in the treatment of HCC unsuitable for standard locoregional therapies.

Materials and Methods

Patients with 1-3 inoperable HCC lesions with diameter ≤10cm were treated by SBRT. According to lesions size and liver function, three prescription regimens were adopted: 48-75Gy in 3 fractions, 36-78 Gy in 6 fractions or 40-50Gy in 10 fractions. SBRT was delivered using the volumetric modulated arc therapy technique with flattening filter free photon beams. The primary end points of this study were in–field local control (LC) and toxicity. Secondary end points were overall survival (OS) and progression free survival (PFS).

Results

Between February 2011 and April 2014, 54 patients with 82 HCC lesions were irradiated. All patients had Child-Turcotte-Pugh (CTP) class A or B disease. Thirtynine lesions (48%) were treated with a dose prescription of 48-75Gy in 3 consecutive fractions, 30 (36%) received 36-78 Gy in 6 fractions and 13 (16%) were treated with 40-50Gy in 10 fractions. Median follow-up was 7 months (range 3-39 months). Actuarial LC at 7 and 12 months was 85% and 74%, respectively. Regimens with Equivalent Dose >100Gy in 3 and 6 fractions was a significant prognostic factors for LC *($p<0.001$)* in univariate analysis Median OS was 12 months and actuarial OS at 1 year was 50%. Univariate analysis showed that OS significantly decreased in the subgroup of patients with Cumulative GTV >5cm *($p<0.008$)*. Median PFS was 7 months, with a 1-year PFS rate of 24%. A

significant (≥ grade 3) toxicity was observed in 9 patients (16%) two-six months after the completion of the treatment. No classic RILD was observed.

Conclusions

SBRT is a safe and effective therapeutic option for HCC lesions unsuitable to standard locoregional therapies, with acceptable rates of local control and low treatment-related toxicity.

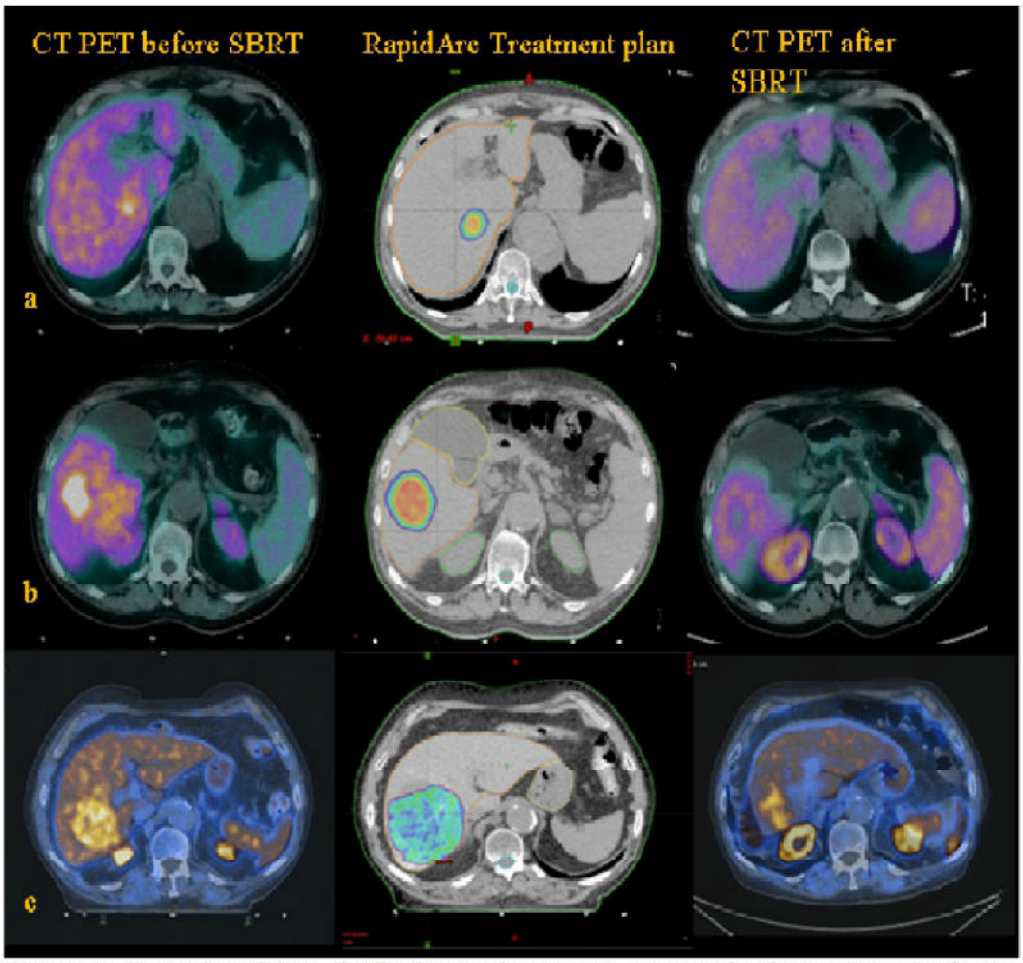

Figure 1: Examples of dose distributions and treatment outcome for three patients in the three fractionation groups (a: 3 fractions, b: 6 fractions, c: 10 fractions).

Role of salvage stereotactic body radiation therapy in postsurgical loco-regional recurrence in a selected population of non-small-cell lung cancer patients.

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Introduction

There are no well-established treatment options for patients with post-operative recurrent non-small cell lung cancer (NSCLC). The NCCN guidelines indicate the concurrent chemoradiation for mediastinal relapse as an evidence level 2A or chemotherapy alone as an evidence level 2B, and there is no specific indication about the isolated recurrence. Furthermore, recurrent disease could be resistant to chemotherapy. In addition, a considerable percentage of patients are unfit for surgical treatment or systemic anti-cancer agents. This is a retrospective analysis of a selected series of high-risk NSCLC patients with post-surgical loco-regional relapse treated with salvage stereotactic body radiotherapy (SBRT). Outcomes and toxicity profile were assessed.

Materials and methods

From 2010 to 2013, 28 patients with 30 lesions underwent salvage SBRT after a 4DCT planning. SBRT was performed as an alternative therapy for patients unfit for surgery or systemic therapy because of advanced age, co-morbid conditions, or no response obtained from other treatments. A pre-treatment 18-fluorodeoxyglucose-positron emission tomography was performed for all patients. The median age was 75 years. The prescribed dose was 23 Gy single fraction for mediastinal nodal recurrences. The total dose was 30Gy in single fraction for peripheral or small tumors (< 30cc). The total dose was 45 Gy in 3 fractions for centrally located or large tumors (≥ 30cc).

Results

Overall, the median PTV was 19 cc (range: 3.6-74.6 cc). The response rate was 86% (CR 16%, PR 70%). In-field local progression was observed in 3 (10%) patients. Regional relapse occurred in 5 patients (18%). Distant progression occurred in 10 (35%) patients. Local control was 96.6% at 1-year and 84.7% at 2 years, respectively. The 1- and 2-years OS were 92.4% and 57.5%, respectively. The 1- and 2-years DFS were 74.3% and 36.6%, respectively. At one month from

SBRT, 21.5% of the patients developed grade 2 pneumonitis. Pneumonitis after 3 months from treatment occurred as follows: 6 patients experienced grade 2, and only 2 patients experienced grade 3 toxicity. Six patients experienced grade 1 lung fibrosis after 6 months.

Conclusions

Several studies reported the employment of radiation therapy as salvage treatment, even though there is still no large controlled trial in the literature. SBRT could have an alternative role in isolated loco-regional relapse in patients unfit or resistant to other type of therapies.

Stereotactic Body Radiotherapy in oligometastatic/oligorecurrent Non-Small-Cell-Lung cancer patients: A new therapeutic approach.

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Introduction

Stage IV NSCLC is characterized by a poor prognosis; nevertheless in patients with limited disease (1-5 metastases), called oligometastatic disease, has been observed a slightly better prognosis. The opportunity for local treatment in this stage of disease is not explored yet, but the management of oligometastatic disease is controversial. We evaluated the impact of a stereotactic body radiotherapy (SBRT) delivered in all active sites in the lung in patients with oligometastatic/oligorecurrent NSCLC. Response, survival, time to progression, sites of progression and toxicity were assessed.

Material and Methods

Twenty-nine lung metastases (within the lung parenchyma) in 22 patients affected by oligometastatic NSCLC were treated with SBRT to all active sites of disease. Inclusion criteria were controlled primary tumor with complete response or stable disease after surgery/radiotherapy/combined therapy, ≤ 4 synchronous or metachronous lung metastases at the time of treatment, and no other active sites of distant metastasis. The prescribed dose was as follows: 23 Gy/single fraction for multiple lesions, 30Gy/single fraction for peripheral or small tumors (< 30cc), and 45 Gy/3 fractions for centrally located or large tumors (≥ 30cc). Toxicities were graded according to CTC AE v4.0 scale.

Results

Most of the patients (72%) were male, and 28% were female. Response to treatment occurred as follow: complete response in 21% of lesions, partial response in 69% of metastases, stable disease in 10%. Ninety-one (91%) patients had complete metabolic response, 9% had a partial metabolic response. Median follow-up was 18 months. The 1-year and 2-years OS was 86% and 49%, respectively. The 1-year and 2-years PFS was 79% and 40%, respectively. Median time to progression and median OS were 18 months and 24 months, respectively. Local control was 93% at 1 year and 64% at 2 years. Local progression occurred in 4 metastases (14%). Overall, acute

toxicity occurred in 18% (4/22) of patients; two patients experienced grade 2 pneumonitis. Grade 1-2 late toxicity occurred in 50% of patients. No grade ≥3 toxicities were recorded.

Conclusion

Local treatment is a feasible and well-tolerated treatment for oligometastatic NSCLC patients. Ablative RT has a potential role in the local control of the lung metastases and in the management of well-selected stage IV NSCLC patients in increasing quality of life and survival.

Feasibility and efficacy of stereotactic radiotherapy in lymph-node metastases.

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Background

Malignant tumors typically metastasize to lymph-nodes. These localizations can arise with associated symptoms or can be, in most cases, asymptomatic. Often node metastases can be the only site of active disease. It is reasonable to treat local metastasis with ablative therapies. Some evidence show that local ablative treatment can achieve a good response and an optimal local-disease control (LC)[1-3]. The aim of this study was to evaluate the feasibility, local control and the potential impact on survivals of stereotactic body radiotherapy in lymph-node metastases in oligometastatic patients.

Materials and methods

Fifty-eight patients with 66 lymph-node metastases (32 male, 26 female) were treated with SBRT between 2009 and 2014. Site of node metastases were as follows: 38 (57,5%) intra-thoracic metastases, 28 (42.5%) abdominal/pelvic metastases. The most common primary site of tumor was lung 22 (38%), followed d by colon-rectum 7 (12%) prostate 6 (10%), stomach 5 (9%), uterus 4 (7%), ovary 4 (7%), breast 2 (3%), melanoma 2 (3%), and others (2%). Single fraction of 30Gy (24%) or 23Gy (26%) was used in 33 lymph nodes. Fractionated schedule was used for the other 33 lymph node metastases. Variables was evaluates as prognostic factors.

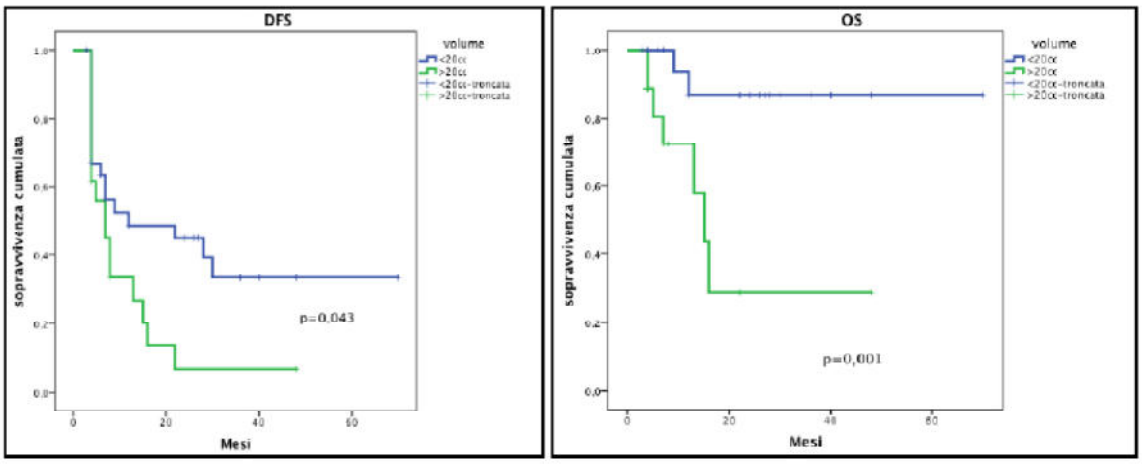
Results

Of the 66 pathological nodes response was achieved as follows: 37 nodes achieved complete response (56.2%), and 17 nodes achieved partial response (25.6%), while 10 lesions had stable disease (15.2%). The progressive disease was observed for only 2 lesions (3%) after SBRT. The observed local control was 93% at 2-years. Disease-free survival was 42.5% at 1-year and 30% at 2-years. The 1-year and 2-years overall survival was 80% and 65.8%, respectively.

The PTV volume (<20 cc) was significantly associated with better DFS (p=0.043) and OS (p=0.001), respectively. For the other variables no impact on survivals was calculated.

Conclusions

Stereotactic body therapy is feasible and safe for the treatment of metastatic lymph-nodes inside the thorax or the abdominal-pelvic area. Also, this treatment is efficient in a selected population of patients presenting oligometastic disease. SBRT can be administered even in patients receiving systemic therapies without increasing toxicity rates.



Stereotactic Body Radiation Therapy for patients with inoperable liver metastases from colorectal cancer: final results of a phase II trial.

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Introduction

To evaluate the feasibility and efficacy of Stereotactic Body Radiation Therapy (SBRT) in the treatment of colorectal liver metastases.

Materials & Methods

Forty-two patients with inoperable colorectal liver metastases not amenable to radiofrequency ablation (RFA), were treated with SBRT for a total number of 52 lesions. All patients received a total dose of 75Gy in 3 consecutive fractions. Mean size of the lesions was 3.5cm (range 1.1–5.4). Toxicity was classified according to the Common Toxicity Criteria (CTC) version 3.0.

Results

Median follow-up was 24 (range 4–47) months. The progression in field was observed in 5 lesions. Twenty-four months actuarial local control (LC) rate was 91%. Median overall survival (OS) was 29.2±3.7 months. Actuarial OS rate at 24 months was 65%. Median progression-free survival was 12.0±4.2 months; 24 months actuarial rate was 35%. No patients experienced radiation-induced liver disease (RILD) or grade $\geq$3 toxicity.

Conclusion

SBRT represents a feasible alternative for the treatment of colorectal liver metastases not amenable to surgery or other ablative treatments in selected patients, showing optimal local control and promising survival rate.

No. of Patients	42
Mean age (range)	67 (43-87)
Gender (M:F)	36:6
No. of treated lesions:	52
No. of liver lesions/pts:	
1	34 (81%)
2	5 (12%)
3	3 (7%)
Size of lesions	
≤ 3 cm	28 (55%)
> 3 cm	24 (45%)
Total Dose / Frs	75Gy/3fr

Table 1: Patient and treatment characteristics.

Vincitore SBRT 2014: Phase II study of FFF-SBRT in 5 fractions for low and intermediate risk prostate cancer.

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Introduction

We evaluated the feasibility and toxicity of a short course hypofractionated SBRT programme with Volumetric Modulated Arc Therapy (VMAT) and Flattening Filter Free (FFF) beams.

Materials and methods

A prospective phase I-II study, started on February 2012. Inclusion criteria were: age ≤ 80 years, WHO-PS ≤2, PSA ≤20ng/ml, histologically proven prostate adenocarcinoma, T1-T2 stage, no distant metastases, no previous surgery other than TURP, no malignant tumours in the previous 5 years, IPSS 0-7.

The schedule was 35 Gy in 5 alternative days. SBRT was delivered with RapidArc VMAT, with 10MV FFF photons. Neo-adjuvant/concomitant hormonal-therapy was prescribed according to risk classification.Toxicity assessment was performed according to CTCAE v4.0 scale. EPIC questionnaires assessed Quality-of-Life.Response was evaluated on ASTRO-PHOENIX definition.

Results

75 patients were recruited in the protocol with a median follow-up of 433 days (48-810);. According to NCCN criteria, 28/75 patients were low-risk and 47/75 were intermediate risk. Median age was 70 years (48-80), median initial PSA was 7.17ng/ml (0.50-17 ng/ml). Median Gleason score was 6 (6-7). All patients completed the treatment as programmed (median 11.2 days). All 75 patients analyzed completed the treatment as programmed. Median treatment time is 126sec (120-136).

Acute Toxicities has been recorded as follow: Rectum G0: 56/75 cases(74%); G1: 14/75(18%); G2: 5/75(6%). Genito-urinary: G0: 24/75(32%) ; G1: 23/75(30%) ; G2: 28/75(37%) . In two G2 urinary acute retention cases, intermittent catheter was needed. No acute G3 or greater toxicity has been found. Initial data of Late toxicity are available for the first 64 out of 75 patients with more than 6 months of FUP: Rectum G0 in 60/64 cases(93%), G1 in 4/64(6%), G2 and G3 were not recroded;

Genito-urinary: G0 in 42/64(65%), G1 in 22/64(34%). No G2 or G3. PSA reduction was documented in all patients; in 4 cases a temporary PSA increase was obsereved between 7 and 14 months to the end of the treatment.

Conclusion

SBRT with RapidArc and FFF beams for prostate cancer in 5 fractions is very well tolerated in acute and late setting. Longer follow-up is needed for assessment of definitive late toxicity data and outcome.

Image-guided SBRT of the prostate, 42 Gy in 7 fractions, for localized disease: radiobiology and preliminary clinical results of a phase-II study.

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Purpose

To evaluate the feasibility and acute toxicity of a phase II study concerning stereotactic body radiotherapy (SBRT) with a dose of 42 Gy in 7 fractions, in patients with localized prostate cancer at low/intermediate risk (according to NCCN score) and risk of lymph node involvement <17% (Roach Index).

Materials and Methods

The probability of biochemical recurrence-free survival (BRFS) from the treatment was estimated by the generalized LQ model , adopting the radiobiological parameters proposed by Pedicini et al [IJRO,87,5,2013] for the low/intermediate risk subgroups. The probability of acute rectal complications was evaluated by the model proposed by Strigari et al [IJRO,73,5,1454 -60, 2009] , while for the estimation of late complications of the rectum and bladder the method LBK, after reduction of the DVH, is employed. For planning, the GTV includes the prostate with the 1/3 proximal seminal vesicles without margin; a margin of 3 mm in all directions around the GTV is used to define the PTV . Dose prescription is the average dose to PTV, with the request V95%>95%. Treatment is delivered with a VMAT technique, with 2 arcs using 6MV photons from a Varian 2300iX linac. To reduce the organ motion, patients are premedicated before treatment with Butylscopolamine. The protocol is based on 3 IGRT intraprostatic fiducial markers, with daily online checks by CBCT. The acute and late toxicity is recorded using the RTOG / EORTC scale. Additional data are collected by means of II-PSS (International Prostate Symptom Score) e IIEF-5 (International Index of Erectile Function)questionnaires.

Results

The radiobiological evaluation has provided an estimate for BRFS of 99% for patients at low and intermediate risk, these values are similar to data reported for other highly hypofractionated

schemes. The estimate of acute rectal toxicity is about 5-9%. In the 37 patients treated so far, there was no acute ≥ G2 gastro-enteric/genito-urinary toxicity, or a worsening of the I-PSS score.

Conclusion

the proposed scheme is estimated radiobiologically more effective than high-dose conventional regimens. The absence of acute toxicity seems to confirm the validity of the adopted NTCP model and could be predictive of late toxicity .

Feasibility and local control in re-irradiation with special techniques (IMRT or SBRT): experience of the European Institute of Oncology.

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Introduction

Modern technologies allow us to perform RT re-treatments limiting toxicity. We retrospectively evaluated the feasibility and the impact on local control of a re-irradiation with special techniques (SBRT or IMRT).

Materials and Methods

Inclusion criteria: adult patients(pts) treated with re-EBRT at our institution between 3/2012 and 5/2013; previous treatment with EBRT or BRT; previous RT/concomitant systemic therapy were allowed (CT chemotherapy, hormone therapy HT) . Re-irradiation techniques: SBRT (CBK or Vero) and IMRT (VERO). Acute and chronic toxicity evaluated by RTOG / EORTC and CTCAE criteria.

Results

63 pts treated between 03/2012 and 05/2013, mean age 62 years (38-87). 70 lesions (ls) treated in total: 1 ls in 56 pts, 2 ls in 5 pts, 3 ls in 1 pt (treated at the same time); 28 of these corresponded to the primary tumor, 13 to regional lymph nodes and 29 to metastasis. Primary diagnosis: lung cancer in 15 pts, breast in 22, gastro-intestinal tract in 7, urologic in 7, gynecologic in 5, head / neck in 4, 1 in the CNS, soft tissue in 1, unknown primary in 1 pt. The re-irradiated districts were chest in 35 pts, pelvis in 18 pts, brain in 14 and head/neck in 3 pts. In 34 pts the treated ls was the only one present at the time of treatment, in 11 pts 2 ls, in 4 pts 3 ls, in 1 pts 5 ls and in 13 pts more than 5 ls. 5 pts received a first treatment in addition to re-irradiation. 62 months (2-324) is the average interval between the re-irradiations. Re-treatment techniques: in 24 ls wasIMRT (Vero) and in 46 ls was SBRT (22 Vero, 17 CBK). The mean number of sessions was 6 (1-20). 8 pts undergoing concomitant CT, 14 pts undergoing concomitant HT, 1 pt both. Mean

follow-up was 5 months (1-11 months) evaluated for 28 ls: no progression in 24 cases, progression 1 case and 3 of them cannot be assessed at the time of follow-up. Toxicity was moderates (G1 and G2) for 22 pts, only 1 case of G4/G3 (RTOG / EORTC-CTCAE). No chronic toxicity for pts treated with CBK (9 evaluated), 1 case of GU: G3/G3 for Vero (9 evaluated). At the time of the analysis 4 pts wewe alive without disease, 16 pts were alive with disease, 3 pts died for disease, 2 pts died for other causes.

Conclusions

The therapeutic option of re-irradiation is feasible in selected patients. In our experience the re-treatments were well tolerated: acute and chronic toxicity were acceptable and local control was good. We need a longer follow-up to assess long-term results.

Abstract Fisici Selezionati

Lung SBRT: a flowchart for decision making from 4DCT to 4DCBCT

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Introduction:

The aim of this work is to create a practical flowchart for the setting and delivery of an accurate SBRT, helping physicians and physicists to make a decision about the strategy of the treatment.

Materials and Methods:

The treatment process was divided into different steps; for each of them a rule for decision making was defined depending on some parameters. In the figure 1 the flowchart is summarized: these steps were selected and carefully analyzed.

Results:

Immobilization: vacuum pillow and the abdominal compressor.

Training: A respiratory training is performed for 2/3 times before CT-simulation using an ABC system to help the patient for visualizing his breath tracking and keeping it regular: training is found to be statistically relevant for the recruiting of the patients in the step #3

4DCT and Contouring: A threshold value was found for the amplitude variance (AV) of the breath: 0.22. Each patient with an AV under this limit is recruited to undergo 4DCT-simulation for drawing the ITV on the average CT. If the value is > 0.22 we only draw CTV on the average CT and define an "ITV" based on statistical considerations.

Margins: from ITV to PTV we apply a set of margins defined by means of Van Herk equation considering penumbra and the prescription isodose (80%).

Prescription dose: The dose prescription (80% isodose) based on the size and site of the target.

Planning: Monaco v. 3.2.2 is used and the protocol AAPM 101 is the reference for the constraints; $MLD_{eq\,2}$ Gy of the ipsilateal lung is calculated. If $MLD_{eq\,2} < 17$ Gy and the other constraints are respected VMAT plan is performed; if $MLD_{eq\,2} > 17$ Gy different strategies are adopted.

QA preplanning : The treatment plan Is checked with Delta 4 Phantom prior to patient delivery. If the percentage of points with Gamma index<1 (2mm; 2%) is above 90% patient is treated, otherwise every step is checked again and, eventually, patient is replanned using static field IMRT.
IGRT: Daily setup is performed with 4D Cone beam CT and a 6D couch; 10 phases of the respiratory cycle are imaged and the movement of the tumor is checked (the radiotherapist may verify if the tumor is moving inside the PTV). The Mid Ventilation image is produced and compared to average CT of the plan to correct for setup errors in 6D .

Conclusion:

The flowchart presented here, results of 10 years of experience at our institute, may help in the decision making process of less expert physician or physicist about the SBRT issues.

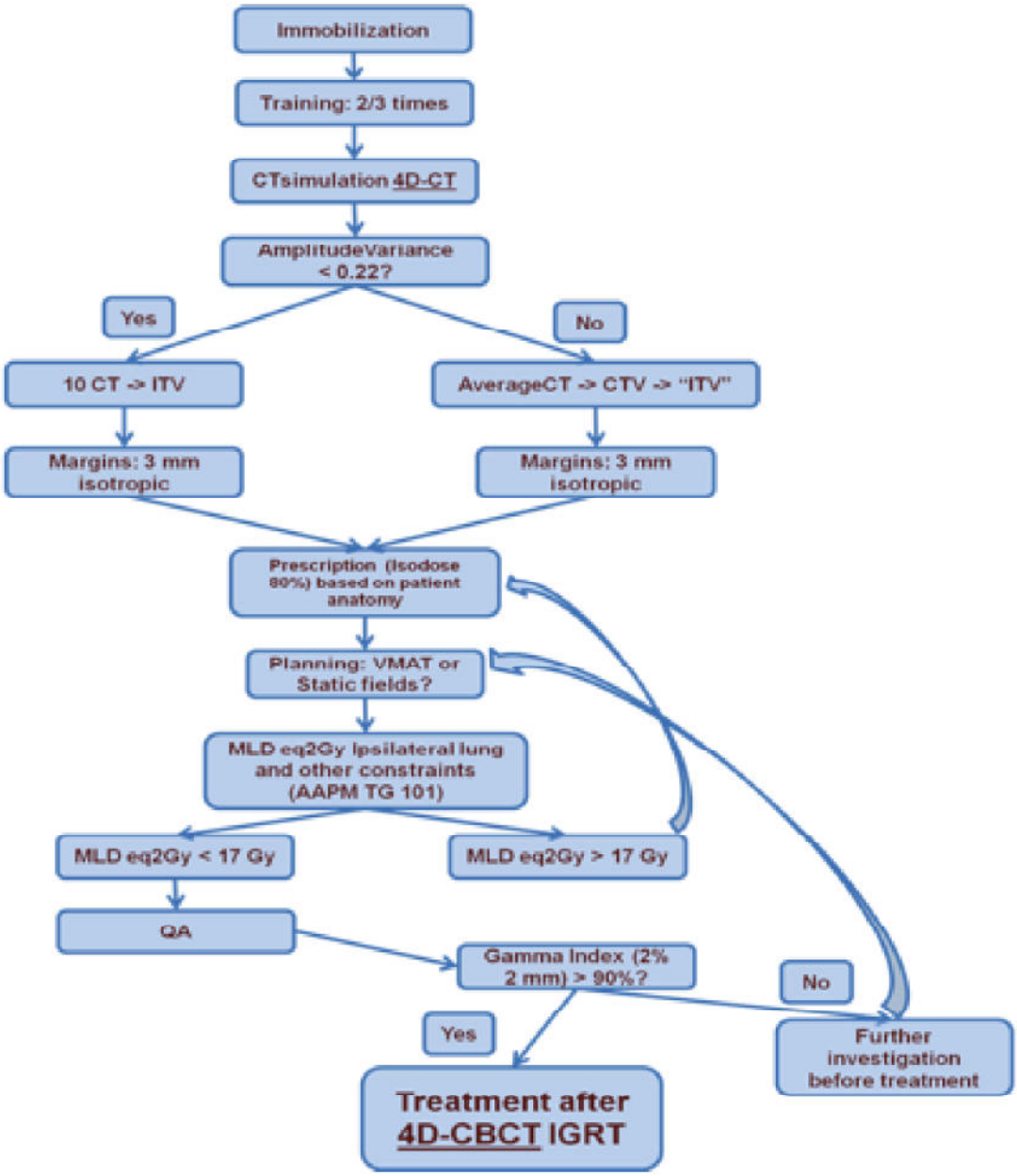

Figure 1 SBRT Flowchart

Dosimetric characterization of a MicroDiamond detector under unflattened beams up to small fields. An experimental and Monte Carlo study.

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Purpose:

With the increasing diffusion of SRS and SBRT treatments, the combination of FFF beams and small fields is becoming of common use and thus the necessity of adequate instruments for dose measurements is compelling. Aim of this work was the characterization of a PTW-MicroDiamond detector under FFF beams.

Methods:

A study in terms of repeatability, dose linearity and dose rate dependence was carried out. The dose per pulse dependence was evaluated up to 0.13cGy/pulse comparing the dosimetric response of the MicroDiamond with the one of a calibrated Farmer-like reference detector. Since changing dose per pulse entails changing the beam energy too, an evaluation of the quality correction factor ($k_{Q,Q0}$) was carried out. $N_{D,w,Q0}$ for the MicroDiamond was measured with a ^{60}Co beam in the ENEA-IMRI Primary Metrology Center. The stopping power ratios (SPR) between diamond and water were calculated with the *sprznrc* module of the EGSnrc Monte Carlo code hence obtaining an approximated $k_{Q,Q0}$ factor. The Varian phase space files of the TrueBeam beams were used as input files and the SPR values calculated for a 10x10cm^2 field at a depth of 5cm and SSD=100cm. $D_{Farmer}/D_{MicroDiamond}$ dose ratios were calculated and the dose per pulse response evaluated. Furthermore a comparison with other detectors and with MonteCarlo simulations was carried out in terms of dose profiles and Output Factors (OF) for fields from 0.6 to 40 cm2.

Results:

Repeatibility and dose linearity were assessed within 0.5% for all energies. Dose rate dependence was evaluated up to 2400 MU/min and deviations <0.5% were observed.

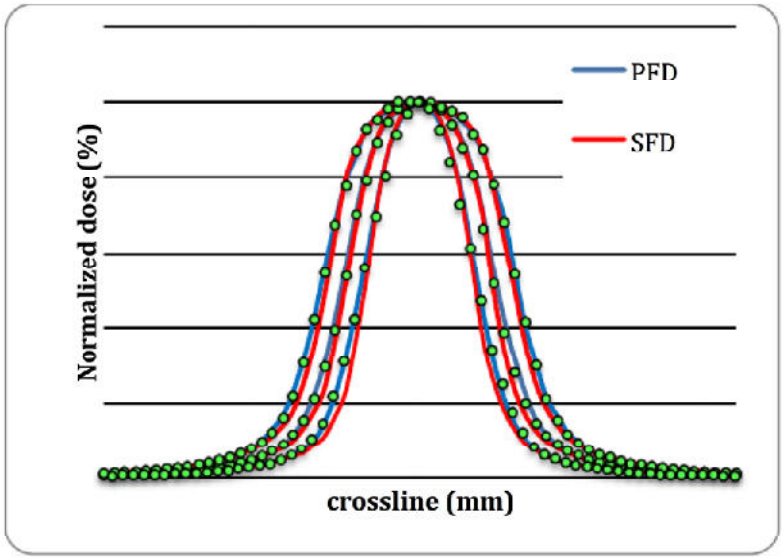
MicroDiamond shows a very good stability with respect to the dose per pulse: the dose differences with the Farmer are ≈1.4% with variations ≤0.2% for all the dose per pulse values. The critical issue is the low sensibility with respect to silicon detectors.

MicroDiamond Output Factors for fields <20x20cm^2 show a good agreement (<0.5%) with the ionization chambers while diodes overestimate the dose for more than 3%. For small fields (<3x3cm^2) MicroDiamond measures ≈3% lower than the shielded diode (whose overestimation is known in literature) and very near to the stereotactic diode measurements. However a particular attention has to be paid to the high physical density that may give some problems for very small field measurements.

The profile measurements show a good spatial resolution comparable to the commonly used solid state detectors.

Conclusions:

The MicroDiamond seems to be an ideal detector for relative dosimetry. It is a very stable detector under FFF beams condition and the combination of a very weak energy dependence and a small active volume makes it adapt for all field sizes measurements in terms of Output Factors and profiles.



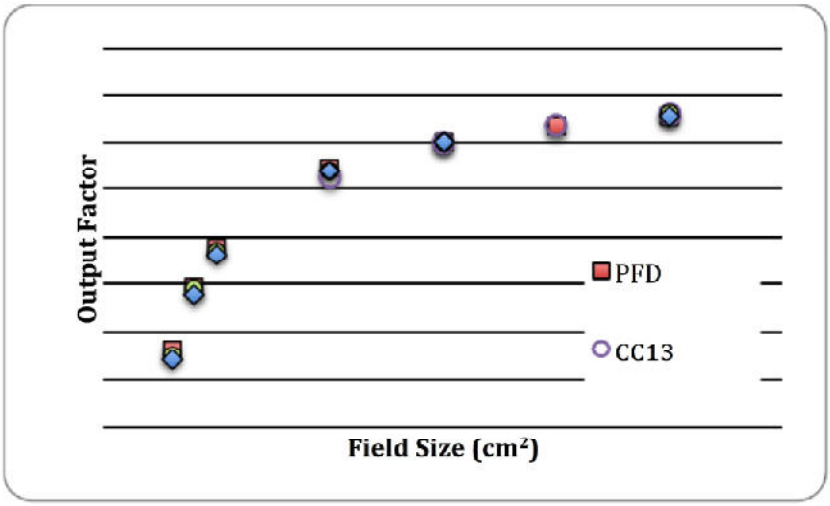


Figure 1 In the figure above profiles for the 0.6x0.6, 0.8x0.8 and 1x1 cm^2 fields for the 10FFF beam are shown. The MicroDiamond shows a spatial resolution comparable to the PFD and slightly lower than the stereotactic diode. In the lower figure the 10FFF Output Factors normalized to the 3x3cm^2 field are shown for 4 detectors.

Commissioning of a real time tumor tracking system using a gimbaled X-RAY head

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Introduction:

The VERO system (Mitsubishi Heavy Industries, Ltd., Japan and BrainLAB AG, Feldkirchen, Germany) is a novel platform for image-guided stereotactic body radiotherapy. Orthogonal gimbals hold the linac-MLC assembly allowing real-time moving tumor tracking. This study aimed to determine the geometric and dosimetric accuracy of the VERO Dynamic Tumor Tracking (DTT) and to evaluate the imaging dose.

Methods and materials:

geometric accuracy was evaluated for gantry 0° and 90° in terms of: prediction error (EP), difference between predicted and detected target positions during the 4D model; mechanical error (EM), difference between tracked by the gimbaled head and predicted target positions; tracking error (ET), difference between tracked and measured target positions. The latter were detected with the X-ray imaging system using a home-developed algorithm. Two moving phantoms were driven based on sinusoidal patterns with amplitudes of 10 and 20 mm, periods from 2 to 6 s and phase shift up to 1 s and on 3 patient patterns. Dosimetric accuracy was evaluated with gafchromic films irradiated in the static as well as in the moving phantom with and without DTT. The imaging dose was assessed using a solid state detector and gafchromic films.

Results:

The RMSs of EP, EM, and ET were up to 0.8, 0.5, 25 and 0.9 mm for all breathing patterns, regardless of gantry angle. ET was caused primarily by EP while EM was negligible. EP and ET increased up to 2.2 and 2.6, for 1 s phase-shifted pattern. DTT significantly reduced motion blurring effects in the dose distribution compared to the non DTT condition even in presence of fast or phase-

shifted motion profiles. For an X-ray beam of 100 kVp and 1 mAs, the ESD per portal due to 20 s fluoroscopy was 16.6 mGy, while treatment verification at 1 Hz frequency contributed with 4.2 mGy/minute.

Conclusions:

The VERO DTT system tracked the target with high accuracy even for fast and phase-shifted motion patterns, leading to dose distributions very similar to the static condition. The hybrid approach guarantees an acceptable level of imaging dose.

Image-guided SBRT of the prostate, 42 Gy in 7 fractions, for localized disease: dosimetric report of a phase-II study

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Introduction

We report our experience of an institutional prostate SBRT phase-II study, which has involved 40 patients, with a focus on treatment planning dosimetry and compliance to the study protocol constraints.

Materials and Methods

Since 2012, 40 patients at low/intermediate risk for localized prostate cancer have been planned for SBRT. Fraction size is 6 Gy for 7 fractions, delivered twice a week, for a total dose of 42 Gy. For planning the GTV includes prostate with the 1/3 proximal seminal vesicles without margin; a margin of 3 mm in all directions around the GTV is used to define the PTV, as the SBRT protocol is based on 3 IGRT intra-prostatic fiducial markers with daily online checks by CBCT. Treatment is delivered with a VMAT technique, with 2 arcs using 6MV photons from a Varian 2300iX linac. Planning was performed in Varian Eclipse 10.0 TPS with the AAA algorithm by 3 different planners. Dose prescription is the average dose to PTV, with the request $V_{95\%}$ >95%. The DVH constraints have been derived from literature and local experience. In addition, the plan quality has been evaluated by means of van't Riet dose conformation number (CN) (*IJRO 1997;37:731*). Dosimetric analysis focused on PTV coverage and organs-at-risk (OAR) sparing, based on key DVH parameters corresponding to protocol constraints.

Results

The main dosimetric results of the first 40 clinical plans are presented in the following table with their compliance to protocol constraints. The PTV is covered by the 95% isodose for all patients, and only the constraint for the PTV near-minimum dose $D_{98\%}$ is not met in 2 cases. As for the OARs, most dosimetric parameters are well within the protocol constraints, with the notable exception of

maximal doses to rectum and bladder ($D_{1\%}$, equal to 95% and 100% of the prescription dose, respectively) for which the constraints are exceeded in about 20% of cases. The mean CN is 0.90 with a CV of 5.5%. The mean value of total MU's corresponds to a delivery of 3.3 min at a doserate of 600 MU/min. Moreover, MU's and CN seem significantly correlated.

Conclusion

Analysis has shown good coverage of PTV and difficulty to meet the constraints relative to the maximal doses of rectum and bladder when these are significantly included in the PTV. As for the measure of plan quality, the average value of CN is well above the 0.80 threshold, while its small CV suggests a consistent application of the planning protocol among the different planners involved in the study.

Structure	DVH parameters statistics				N. of pts with minor deviations
		mean	CV	Constraint	
PTV Vol=115.6 cc (CV=26.9%)	D_{median}	100.0%	0.8%	--	
	$V_{95\%}$	97.4%	1.2%	≥ 95%	0
	$D_{98\%}$	94.7%	1.3%	≥ 93%	2
	$D_{2\%}$	104.9%	1.4%	≤ 108%	0
Rectum Vol=57.8 cc (CV=28.0%)	$D_{1\%}$	37.9 Gy	18.1%	≤ 40 Gy	9
	V_{37Gy}	3.2%	47.5%	≤ 5%	3
	V_{32Gy}	7.7%	31.3%	≤ 10%	2
	V_{20Gy}	30.6%	11.2%	≤ 35%	0
Bladder Vol=139.7 cc (CV=52.2%)	$D_{1\%}$	40.7 Gy	3.8%	≤ 42 Gy	7
	V_{38Gy}	5.4%	122%	≤ 13%	3
	V_{33Gy}	8.2%	52.2%	≤ 30%	2
	V_{21Gy}	22.4%	40.5%	≤ 40%	0
Rt Femoral Head	D_{mean}	6.6 Gy	28.4%	≤ 10 Gy	3
	$D_{1\%}$	13.5 Gy	25.9%	≤ 20 Gy	0
Lt Femoral Head	D_{mean}	6.5 Gy	30.7%	≤ 10 Gy	1
	$D_{1\%}$	13.6 Gy	24.2%	≤ 20 Gy	0
Penile Bulb	D_{mean}	10.2 Gy	53.3%	≤ 21 Gy	2
	$CN_{95\%}$	0.90	5.5%	≥ 0.80	0
	MU	1956	14.9%	--	

Table: Dosimetric results and number of patients with minor deviations in the 40 patient sample.

CV=coefficient of variation (relative standard deviation)

$CN_{95\%}$ = Conformity Number=$(TV_{95})^2$ /(TV · V_{95}) where TV is the volume of the PTV, TV_{95} and V_{95} are the volume of PTV and of the body enclosed by the 95% isodose, respectively.

Comparison of different dosimetric systems for VMAT pre treatment quality assurance in SBRT.

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Introduction

The dosimetric implementation of stereotactic treatment with VMAT represent a challenge because of the small fields involved, the variation of dose rate, gantry speed rotation and leafs movements during the irradiation. Due to the high complexity and uniqueness of VMAT treatment plans, patient-specific pre-treatment quality assurance (QA) is considered a necessary prerequisite to patient treatment. Aim of this work is to compare the capability of two ionization chamber systems (PTW Octavius 4D 729 and PTW Octavius 4D 1000 SRS) and an electronic portal imaging dosimeter (Dosimetry Check) to correctly measure the dose on a homogeneous phantom.

Materials and Methods

PTW Octavius 4D 729 is a 2D array of 27x27 gas filled 5mm x 5mm x 5mm ionization chamber. The detector spacing is 10 mm center-to-center, 5mm edge-to edge. PTW Octavius 4D 1000 SRS, consisted of two-dimensional detector array based on 977 liquid-filled ionization chamber, on a 10x10 cm field. The detector size is 2.3 mm x 2.3 mm x 0.5 mm. In the inner 5.5 × 5.5 cm^2 area of the array, the centers of adjacent chambers are placed at a distance of 2.5 mm from each other. Dosimetry Check (DC) is a software that uses EPID measured fluences of the treatment fields/arcs to reconstruct the dose distribution on a CT study.

SBRT VMAT plans have been generated by Monaco with energies of 6 MV and 10 MV. Seven treatment plans have been used in this comparison (5 lung tumours and 2 pelvic nodes). The QA maps were computed on the synthetic Octavius 4D phantom. Portal imaging QA was performed in air and the fluence obtained from the analysis of the acquired QA was used for computing dose on the phantom. 2D isodose distributions in the principal planes through the isocentre, 3D dose distributions and 3D γ metric at 2% 2mm have been used to compare measured and computed maps.

Results

The results, in terms of percentage of points with $\gamma < 1$, are shown in table1. SRS shows the best agreement with the computed maps (98,5% point with $\gamma < 1$). Despite 729 has a good agreement in term of 3D γ metric at 2% 2mm, along the gun-target (G-T) direction, in the high gradients region, we found a trend to underestimate the dose (see Figure1).

Conclusion

All dosimeters analyzed showed a good agreement with the computed map in term of 3D γ metric at 2% 2mm. The DC and the SRS, have very high data density compared to the more discrete 729 measured points in the G-T direction and this results in a better resolution in the high gradient regions.

	DC	SRS	729
plan1	91 .1	99 .9	97 .9
plan2	96 .1	98 .5	98 .5
plan3	98 .1	98 .3	96 .4
plan4	94 .6	99 .9	90 .6
plan5	96 .1	99 .9	95 .8
plan6	95 .3	96 .1	98 .8
plan7	95 .1	96 .7	99 .1

Table1: Percentage of points with $\gamma<1$ in 3D for the Dosimetry Check (DC), the PTW Octavius 4D 1000 SRS (SRS), PTW Octavius 4D 729.

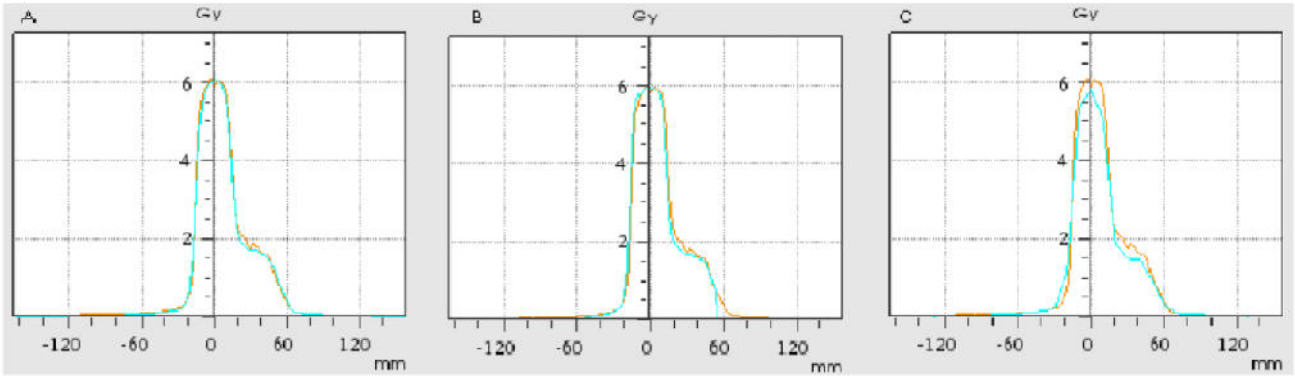

Figure1-In this figure the G-T profile at the isocenter is shown. Yellow line represent the calculated map, and the green line is the measure: A Dosimetry Check, B PTW Octavius 4D 1000 SRS (SRS), and C PTW Octavius 4D 729.

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FFF VMAT SBRT of prostate cancer: impact on target dose coverage and rectal dose sparing from a slightly increased near maximum target dose, and from SpaceOAR® hydrogel insertion.

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Introduction:

By constraining D_{1cc}<35Gy for rectum, bladder, and urethral-PRV, and $D_{2\%}$ ≤37.5Gy for PTV, our current 35Gy in five fractions SBRT VMAT planning on patients without spacer assures $PTV_{33.2Gy}$ ≥95% only. Looking for an improved $PTV_{33.2Gy}$ ≥98%, here we report our computations by combining a slightly increased near maximum target dose ($D_{2\%}$ ≤40.2Gy) with SpaceOar® hydrogel (spacer) insertion.

Materials&Methods:

For eleven patients four two-arcs VMAT (RapidArc ®) plans, by 'Eclipse' TPS (v. 10.0.28) with 10MV-FFF beam from a 'TrueBeam' (® Varian) linac, were planned. Each CT-scan, with (*Spc*) or without (*NoSpc*) spacer, was used for computing two plans, both assuring D_{1cc}<35Gy for rectum, bladder, and urethral-PRV, and $PTV_{33.2Gy}$ ≥95% at least: *Hom* plans, with $D_{2\%}$ ≤37.5Gy, and *Het* plans, with $D_{2\%}$ ≤40.2Gy. Median/mean values from the four groups of plans for target dose coverage ($D_{98\%}$, $D_{50\%}$, $PTV_{33.2Gy}$, PTV_{35Gy}), and for rectal dose sparing (V_{18Gy}, V_{28Gy}, V_{32Gy}), were then compared (Wilcoxon or *t*- test). Finally, linear correlation and ANOVA analyses between the variations resulting from spacer insertion in the fractional overlaps with PTV of rectum (DV^{r}_{ovl}) alone, or of the sum of rectum, bladder, and urethral-PRV (DV_{ovl}), and the corresponding variations in $PTV_{33.2Gy}$, and in rectal V_X, were performed.

Results:

By comparing plans of equal allowed $D_{2\%}$, the impact of spacer insertion resulted in a significant reduction in rectal V_{18Gy}, V_{28Gy}, and V_{32Gy}, and in an improved target dose coverage for $D_{98\%}$ and

$PTV_{33.2}$. By comparing plans at equal spacer insertion status, the impact of the increased allowed $D_{2\%}$ was estimated in a significantly improved target dose coverage ($D_{50\%}$, $PTV_{33.2}$, PTV_{35}), whereas no significant rectal dose sparing was computed. Finally, the direct comparison of *Het-Spc* vs. *Hom-NoSpc* plans resulted in significant improvements for all of the conceived parameters: in Figure 1 such comparison is further shown in terms of mean DVHs. For the increases in $PTV_{33.2Gy}$, from spacer insertion in *Hom* plans, a significant linear correlation was found with the corresponding reduction of DV_{ovl}, but not of DV^{r}_{ovl} alone. By contrast, DV^{r}_{ovl} significantly correlated with V_{32Gy} and V_{28Gy}, whereas DV_{ovl} did not. ANOVA finally supported DV^{r}_{ovl} from spacer insertion as effective source of variation for V_{32Gy} and V_{28Gy}, but not for $PTV_{33.2Gy}$.

Conclusions

A slightly increased $D_{2\%}$ (≤40.2Gy) improved target dose coverage, but not rectal dose sparing, whereas spacer insertion improved both rectal dose sparing and target dose coverage. With spacer insertion, however, the observed increase in $PTV_{33.2Gy}$ did not linearly correlate with the reduction of DV^{r}_{ovl}, neither ANOVA supported DV^{r}_{ovl} as effective source of variation for $PTV_{33.2Gy}$. We then believe that spacer insertion can be identified as a causal source for the observed improvement in rectal dose sparing, but not in target dose coverage. Nevertheless, it was only by the combined use of spacer insertion and increased accepted $D_{2\%}$ that our target dose coverage goal – $PTV_{33.2Gy}$ ≥98% – was assured.

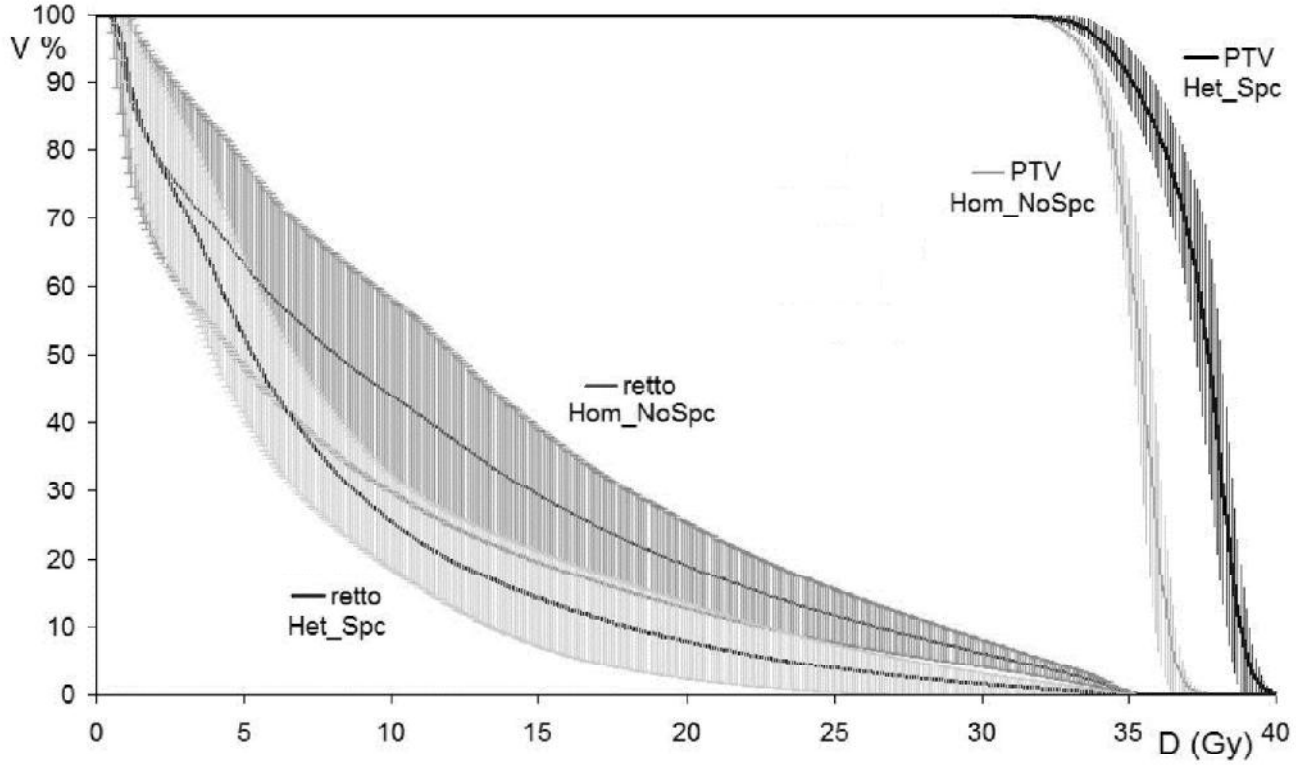

Figure 1: Mean DVHs (error bars: ±s), averaged over 11 plans, for rectum and PTV when comparing *Het-Spc* vs. *Hom-NoSpc* plans. The enlargement of the therapeutic window by the combined use of spacer insertion and increased accepted $D_{2\%}$ is evident.

Pre-treatment verification of stereotactic body fluence modulated plans

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Purpose

Pre-treatment verification of intensity modulation radiotherapy (IMRT) plans is generally performed as a good practice, in order to disclose calculation or delivery problems. This test is particularly important for high dose per fraction treatments, such as SBRT ones, because inaccuracy in dose delivery could result in potential or effective damages to the patient. In our Centre, we generally use step and shoot IMRT techniques for SBRT treatments and we perform pre-treatment verifications by means of a diode matrix. In this work, we propose to improve the spatial resolution of dose measurements using images from an on board linac portal imaging device (EPID).

Material/Methods

IMRT beams from a SynergyS linac and calculated by Oncentra (Elekta, SE) are routinely verified with Mapcheck2 (Sun Nuclear, USA), a diode matrix, with a diode distance of 5 mm. As stereotactic beams have small dimensions and high dose gradients, Mapcheck2 is not an optimal choice, because of the poor number of points of measurements. It is possible to use EPID iViewGT (Elekta, SE) to "get" a high resolution picture of treatment fields.

Since EPID is not a dosimetric tool, a dedicated sw EPIDose (Sun Nuclear, USA) was used to perform EPID response to dose map conversion. The generated conversion model was tested against standard conformed beams and with some IMRT beams.

A 2%, 2 mm gamma test (global and local) with a 10% threshold was performed for simple conformed beams, and with a 3%, 3 mm (global and local) for IMRT beams.

Mapcheck2 and EPIDose data sets were compared to calculated IMRT stereotactic plans. A monitor unit rescaling was also applied for each beam, in order to reduce ghost artifacts.

Results

Five IMRT stereotactic plans (9 beams for each plans) were delivered with SynergyS 6 MV X-ray beams. Each beam was acquired with both Mapcheck2 and iViewGT.
Preliminarily results on Gamma analysis for Mapcheck2 and EPIDose comparisons to calculated dose are nearly the same in terms of passing rate (>95% for both systems), but differences are pronounced in region at high gradient in which EPIDose can use a better spatial resolution.

Conclusions

EPIDose processed iViewGT images can be routinely used for pre-treatment verification of stereotactic SynergyS 6MV plans. The high resolution made this device usable also in small SBRT beam dosimetry. The acquisition and analysis of these images are fast and reliable, and all measures can be easily performed by radiation technologists.

Stereotactic Body Radiotherapy (SBRT) of lung cancer with the new machine VERO

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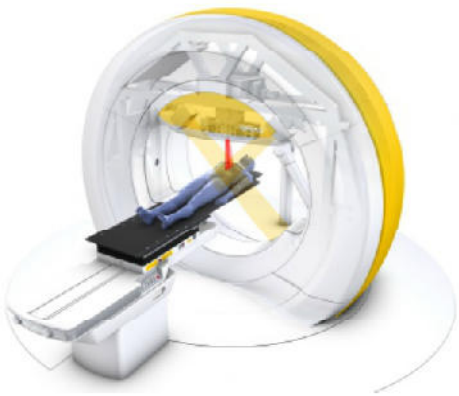
Introduction

The developments in 3D/4D images, treatment planning systems and treatment delivery machines have lead to a more accurate radiotherapy. Stereotactic Body Radiotherapy (SBRT) is an example of high dose fraction delivery with high level of accuracy.

Materials and Methods

At St. Anna Hospital in Como since March 2011 to May 2014 we have performed SBRT with VERO on 17 patients (23 lesions) with NSCLC, T1-T2a stadium, not elegibile for surgery, and with oligometastases. The Vero is a monoenergetic 6MV linear accelerator with 0.1 mm isocenter position accuracy. Beam profiles with 3mm of penumbra are defined by a multileaf collimator (MLC) of 5mm width at isocenter. Vero is equipped with an infrared camera system (ExacTrac-ET) for patients positioning and a robotic couch with 5 degrees of freedom. Fine set up corrections for IGRT (Image Guided Radiotherapy) treatments are based on two-dimensional KV-images or volumetric ones (CBCT) acquired with two orthogonal X-ray tubes. The ET is able to monitor the patient's breathing giving on line shifts from set up position, so as immobilization system we use only a wing board for arms and a vacuum for chest.



The Radiotherapy Treatment Planning System (RTPS) IPLAN (BrainLab) works with two algorithms: Pencil Beam (PB) and Monte Carlo (MC). The study of comparative plans with both PB and MC have led us to choose the 90% isodose PTV coverage with PB (equal to 80% isodose coverage with MC).

The PTV is obtained by adding a 5mm margin to ITV resulting from the union of four CTVs outlined on four CT series (Basal, Slow, Maximum inhale, Maximum exhale). The prescription doses, 100% of prescription dose to 50% of PTV volume, are lesion position related. For central lesions a fractionation scheme of 10Gy x 5 or 7.5Gy x 8 is used, for peripheral ones the fractionation schemes are 12Gy x 4, 15Gy x 3, 18Gy x 3 or 20Gy x 3. All treatments are delivered using one or two conformal dynamic arcs with 3mm PTV_MLC margins.

Results

Conformal dynamic arcs assure a sharp dose gradient (distance between PTV margin and 50%isodose line less than 2cm) and the respect of OAR dose constraints fixed in RTOG protocols. The follow-up is short to give any conclusion about tumor control probability and disease free survival. We have noted low toxicity, only asymptomatic pneumonitis.

Conclusions

Vero machine is found to be a suitable accelerator to perform SBRT. Patients will not be moved during the entire treatment because the machine will move around them (Gantry, O-ring, head tilt) and integrated systems for the of 2D and 3D images acquisition ensure high precision treatments.

EPID Dosimetry: a useful tool for PreTreatment patient-based QualityAssurance?

VILLAGGI E.

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Introduction

SBRT has evolved from a technology used only in specialized centers to a widely spread method. Nevertheless, in literature there are few data on performance of the delivery during SBRT treatment by linear accelerator's beams, in particular by Volumetric Modulated Arc Techniques (VMAT). Conformity and homogeneity with individual heterogeneity in SBRT plans could be assessed by the remarkable amount of 3D data by an EPID (Electronic Portal Imaging Device) dosimetry pre-treatment Quality Assurance (QA).

Materials and Methods

Varian Eclipse treatment planning system was used to planning VMAT treatments in different treatment sites (lung, liver, prostate). Treatments were planned using a Varian linear accelerator's 6 MV photons beam. EPID images were acquired in cine-mode by a Varian aS1000. Calculations were performed using Dosimetry Check software (Math Resolutions LLC). Further, isocenter point dose measurements were performed by a microchamber (CC01 Scanditronix Wellhofer) in a water equivalent ellipse-shaped phantom.

Gamma Analysis in 3D was performed using global 3% 3 mm gamma criterion. Dose distributions, point doses, gamma distributions and DVH statistics were compared.

Median (D50), minimum (D95) and maximum (D05) PTV doses as well as doses delivered to the GTV are analyzed in terms of comparison between planned and measured doses. OAR values used during planning are reported.

Results

Absolute differences in isocenter points (both chamber and EPID measurements) are within 3%. EPID dosimetry was used to calculate sagittal, axial and coronal planes gamma evaluation; 3D gamma index and 1-percentile of the 3D gamma distribution were assessed. PTV, GTV and OAR's DVH measured by EPID dosimetry are used to clinically quantify the performance of the plan. Lung results depends on amount of air in the treatment field. Figure 1 reports an example of gamma image in a prostate case (prescription dose 35 Gy, 5 Gy/fr).

Conclusion

EPID dosimetry is an interesting tool in SBRT planning: quick experimental setup demands minimal time machine and a lot of clinical data are available to guarantee both accuracy and flowing delivery of a SBRT plan. DVH comparison is an unusual and instant tool to assess clinically plan's quality performance. More research is needed to assess optimal values for alert criteria.

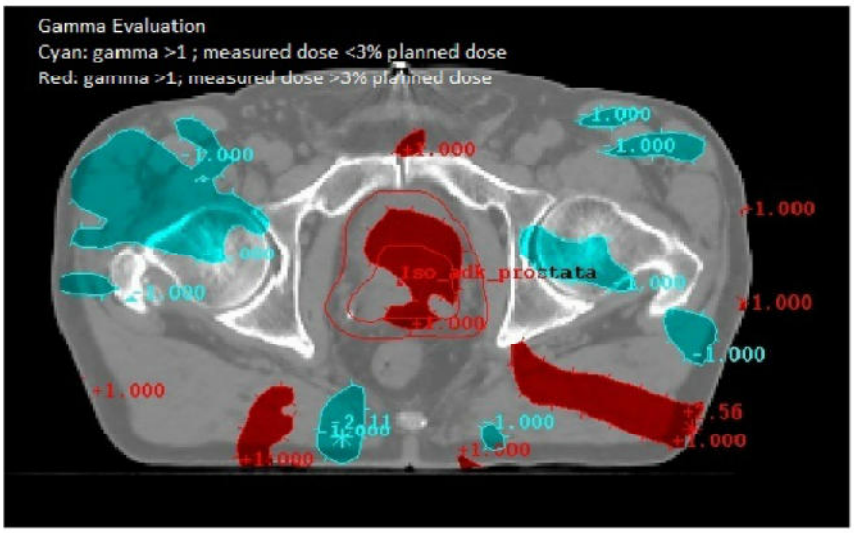

Figure 1: 3D gamma evaluation

Intrafraction motion assessment in SBRT for prostate cancer: a prospective study

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Purpose

Stereotactic Body Radiation Therapy (SBRT) for prostate cancer is a technically demanding treatment in terms of target localization. In this study, a temporary implanted wired electromagnetic tracking system was employed in prostate treatments with standard fractionation, to investigate the impact of motion for future SBRT prostate cancer treatments at our department.

Materials and methods

A group of 9 patients treated with radiation therapy (dose 70.0 Gy, 2.5 Gy/fraction) of the prostate gland was studied. Each patient was implanted with two gold seeds and an electromagnetic transmitter in the prostate gland, which was surgically removed at the end of therapy.

The tracking system (Raypilot System, Micropos Medical AB), an add-on device to the linear accelerator composed by the implanted transmitter and a flat receiver placed on the patient bed, provides the 3-D real-time position of the transmitter itself, which is passively employed as a surrogate of prostate motion. Target is monitored during every treatment fraction without affecting radiation beam delivery.

Both interfraction and intrafraction motion displacements were recorded. CTV-to-PTV margins were retrospectively assessed with Van Herk's method. The plan robustness analysis function in CERR (Computational Environment for Radiotherapy Research, Washington University) was used to simulate the DVH uncertainty with measured systematic and random shifts. PTV coverage and dose ranges for a set of OAR's were evaluated.

Results

Transient excursions, typically within 20 seconds duration, and drifts of the prostate gland were observed during treatment. Spatial displacements > 11 mm in the cranial-caudal direction were identified in 1 patient, > 4 mm in the cranial-caudal and anterior-posterior directions in 3 patients, < 4 mm in the remaining patients. Evaluated CTV-to-PTV margins are shown in *Table*.

Concerning robustness plan analysis, more than 98% of PTV is covered by 95% of prescription dose. The mean values of the DVH uncertainty ranges (upper / lower range bound with respect to the planned dose) is (+1.5% ; -2%) and (+2.7%;-13.1%) at V_{68Gy} for rectum and at V_{60Gy} for bladder respectively.

Conclusions

This prospective study suggests: a) intrafraction motion impact on treatment margins should be considered; b) variation in DVH analysis for bladder and rectum are not negligible. Therefore target repositioning or beam-gating techniques should be considered in the therapy execution protocol.

Measured interfraction motion (cm)				Measured intrafraction motion (cm)			
	AP	CC	LR		AP	CC	LR
Mean	-0,027	-0,075	0,026	Mean	0,005	0,011	0,008
Σ_{inter}	0,098	0,222	0,072	Σ_{intra}	0,044	0,027	0,026
σ_{inter}	0,221	0,296	0,183	σ_{intra}	0,188	0,123	0,084

Margins (cm)			
	AP	CC	LR
excluding intrafraction motion	0,401	0,763	0,309
including intrafraction motion	0,472	0,784	0,333
difference	0,071	0,021	0,024

Table. Evaluated prostate margins for a group of 9 patients. AP= anterior - posterior; CC = cranial - caudal; LR = left- right. Σ = sistematic error; σ = random error

Intercomparison of small field output factor measurements for a 6MV photon beam

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Introduction

Nowadays, the development of new dosimeters to be used in a quality assurance program, where uncertainties due to small field measurements could introduce systematic errors to the dose delivery is a challenge. Dosimeters with an intrinsic high spatial resolution are necessary for field size and penumbra measurements of small fields, which are increasingly used in high conformai treatments like intensity-modulated treatments (IMRT), Volumetric Modulated Arc Therapy (VMA T) and stereotactic treatments. However, small photon beam measurements are problematic, mainly due to the presence of high dose gradients and the lack of lateral electronicequilibrium in narrow photon beams. Dosimeters used for such measurements should ideally exhibit certain characteristics such as being tissue-equivalent and not perturbing the radiation beam, exhibiting energy, dose rate, and angular independence of response, having small sensitive volume and ability for high spatial resolution measurements, and overcoming the positioning problems that are usually present in small field dosimetry.

In particular the aim of this work is to analyze the agreement between the output factors of 6MV photon beam performed using A1SL chamber, Gafchromic film, a diamond detector, and a silicon diode. Measurements with silicon and diamond dosimeters have been already published by some of the authors [NIM-A 658 (2011) 84-89., Med Phys. 2013 Sep;40(9):092103], and here have been integrated with Gafchromic and ionization chamber data.

Materials and methods

An Elekta Synergy Beam Modulator Linac was used for the beam delivery. Dosimeters employed for measurements were a single crystal diamond detector developed at the University of Rome Tor

Vergata, a silicon diode of a bidimensional matrix developed in the framework of the. European project MAESTRO, an Extradin A1SL ion chamber and EBT3 Gafchromic film (Ashland). Diamond sensitive volume is a cylinder 2.2mm in diameter and about 1 ~m thick, placed 0.8 mm from the detector tipo MAESTRO diode was the centrai pixel of a sensor manufactured by implanting a matrix of 21 x21 n+ /p squared diodes (2x2mm2 active area and 3mm pitch), separated by a guard-ring network, on a 50 ~m thick p-type epitaxiallayer.

The commerciai IBA l'mRT phantom, made of a water equivalent material (RW3) was used for output factor measurements.

Ali the detectors, but the silicon diode, were positioned with their axis perpendicular to the beam axis, inside the commerciai IBA l'mRT phantom. MAESTRO matrix was sandwiched in solid water in order to have an equivalent experimental set up.

Results

The results of the output factor measurements are shown in the following figure. All the measurements are in in good agreement, especially GAF, A1SL and SCDD which have the same experimental set-up. The maximum deviations reported are related to the field O.8xO.8cm2 for MAESTRO and A1SL data respect to the GAF (around +15% (A1SL vs EBT3) 16 % (MAESTRO vs (EBT3)).

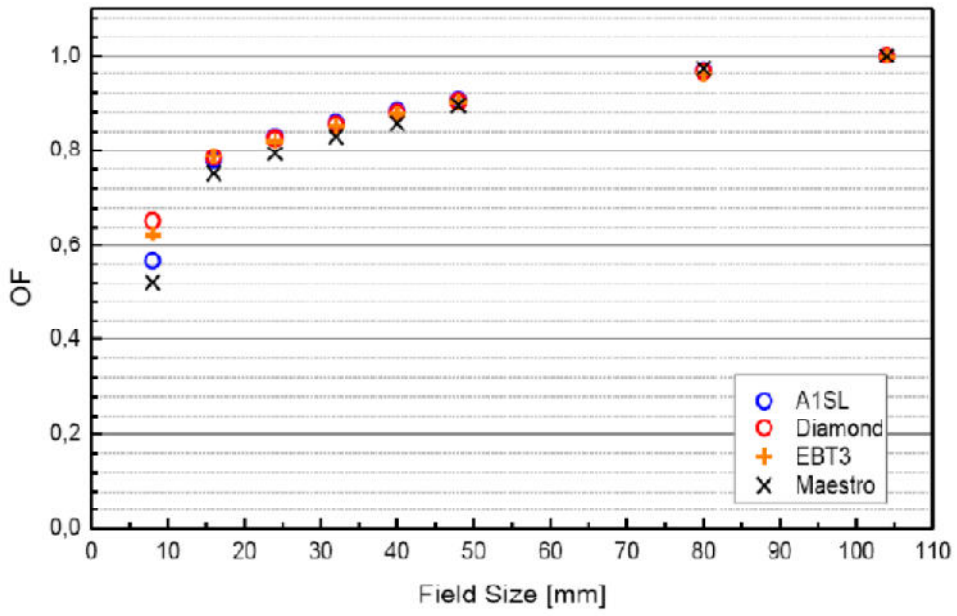

Figure 1: Output factor comparison with different methods.

Conclusion

In this work measurements made with a variety of detectors have been compared. To further investigate the causes of measurement variations between detectors for very small fields, a comparison with the Monte Carlo model of small field dose calculations is needed.

Patient-specific quality assurance for Cyberknife treatments with radiochromic film

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Introduction

The increased complexity of advanced radiotherapy techniques, such as Cyberknife stereotactic radiosurgery, requires a Quality Assurance (QA) program in order to verify the accuracy of the delivery of clinical doses. This study is finalized to implement in the clinical practice a pre-treatment QA method based on radiochromic film 2D dosimetry.

Materials and methods

A total of 60 treatment plans, with target volumes from 0.03 to 181 cc and planned maximum doses ranging from 6 to 21 Gy, is evaluated. The comparison between the delivered and calculated dose is based on the Gamma analysis method performed with an home-made MATLAB® code, using 4% local Dose Difference (DD) and 2 mm Distance To Agreement (DTA) criteria, and also reducing the DD to 3%. The analysis is executed with a combination of the red and green channel response, considering the red channel for planned doses below 10 Gy and the green channel for doses above 10 Gy. Different threshold doses (TD: % of the planned maximum dose) are selected for the Confidence Index (CI) evaluation. [Fig. 1]

Results

The analyzed plans exhibit an overall average CI of 91%(10%) for a threshold dose of 50% and 89%(8%) for a threshold dose of 20% , with 4% and 2 mm criteria. Reducing DD to 3%, the analyzed plans show a CI of 87%(11%) for a threshold dose of 50%

Conclusion

The method proposed has shown a good agreement between the planned and measured dose distributions, both within the high dose region nearer to the target (TD 50%) and in the low dose region that includes critical structures (TD 20%). The use of a double channel Gamma analysis has proven to be effective in increasing this accordance, taking advantage of the characteristic dose

response of radiochromic EBT2 in the red and green channels. The next improvements of this QA include:

- the reduction of the Gamma-Index criteria, in particular DTA 1 mm, with an improvement in the registration of the images and with the use of a phantom that guarantees a more rigorous positioning of the film;
- the use of a dedicated software that provides both the Multichannel Film Dosimetry (Micke et al.), to further optimizes the response of radiochromic films and the One Scan Protocol, to scan the film after only 15 minutes from the delivery.

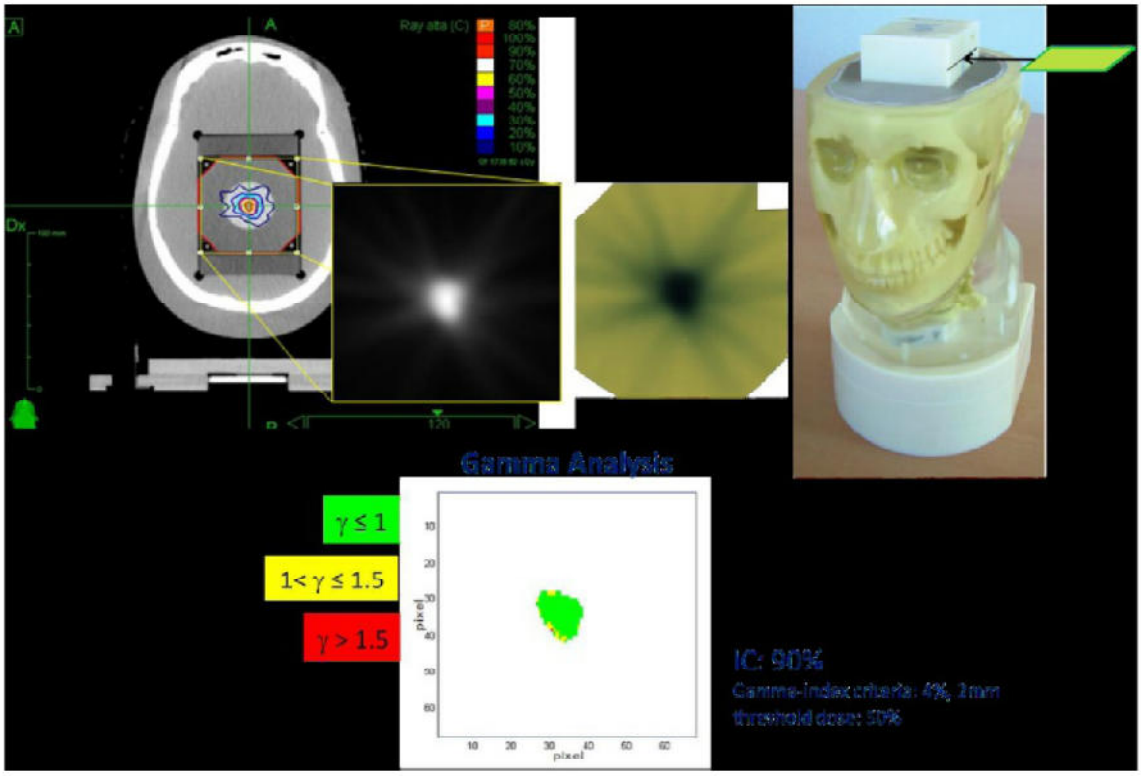

Figure 1: Gamma agreement index evaluation.

Preliminary analysis of Dose-Volume & Dose-Surface Histograms (DVHs & DSHs) in Stereotactic Body Radiation Therapy (SBRT) for prostate cancer

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presenting author, oral presentation, Physics, Award nomination

Introduction

A SBRT protocol for the treatment of prostate cancer with Volumetric Modulated Arc Therapy (VMAT) is active at INT: the irradiation of the prostate gland (PG) up to 18Gy (9Gy/fraction) is followed by pelvic irradiation (50Gy, 2Gy/fraction). The Planning Target Volume (PTV) for SBRT is defined as the PG plus a 2mm margin in all directions. A urethral catheter is used to identify the urethra and to keep the bladder filling at a constant volume, whereas gold fiducial markers are implanted in the PG for its localization by means of kV-CBCT. CBCT images are acquired before delivery, mid-treatment and at the end of the treatment to verify patients' position.
Aim of this study is to evaluate reliability of the SBRT protocol, in terms of setup reproducibility, target coverage, dose to the main Organs At Risks (OARs) and possible toxicities.

Materials and methods

PTV, bladder and rectum were contoured on the CBCT images for 6 patients. PTV variations and displacements of its centre were compared to the planned values. The original VMAT plans were recalculated on the pre-treatment CBCT images. To compare PTV coverage, mean dose and the percentage of volume receiving 95% ($V_{95\%}$) of the prescribed dose (PD) were considered, as well as possible hot spots. For OARs, mean values and standard deviations of the absolute volume and surface receiving 95% and 75% of the PD were considered. Besides, rectal and genito-urinary (GU) acute toxicities were recorded.

Results

The mean variation of the PTV was 2.8±1.6% compared to the planned values and the calculated displacements of its centre were on average 0.4±0.4 mm, suggesting accurate image registrations performed during the treatments and the absence of relevant deformations. PTV coverage did not change significantly compared to the planned one, besides no hot spots were found in the target. Dose statistics of the OARs are reported in Table 1. Neither rectal nor GU severe acute toxicities were recorded at the end of the SBRT treatment, as well as at the end of the whole treatment: 2 G1 cases for GU toxicity.

	DVH		DSH	
	$V_{95\%}$ (cm^3)	$V_{75\%}$ (cm^3)	$S_{95\%}$ (cm^2)	$S_{75\%}$ (cm^2)
Bladder	2.17 ± 2.13	8.20 ± 2.90	13.46 ± 5.75	27.93 ± 5.83
Rectum	0.32 ± 0.49	2.72 ± 1.39	3.74 ± 3.71	14.93 ± 5.30

Table 1 – $V_{X\%}$ and $S_{X\%}$ = absolute volume and absolute surface receiving X% of the PD, respectively

Conclusion

The preliminary results highlight a good reproducibility of the SBRT protocol. DVH and DSH analysis suggests that volumes and surfaces of rectum and bladder encompassed by high dose are small enough to avoid significant toxicities, even after pelvic irradiation. Moreover, the PTV margins seem to ensure a good coverage. Lastly, SBRT with VMAT allow to achieve homogeneous dose distributions in the target, avoiding possible hot spots in the urethra.

Estimation of Planning Target Volume in stereotactic body radiotherapy (SBRT) protocol for non small cell lung cancer (NSCLC)

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Introduction

To evaluate the uncertainties in stereotactic body radiotherapy for lung tumours and to quantify Planning Target Volume.

Materials and Methods

SBRT protocols for NSCLC at our hospital consider both primary tumours and metastasis, with dose prescriptions of 60Gy/5fx for peripheral tumours and 50Gy/10fx for centrally located lesions. RTOG0915 and 0813 guidelines are used for plan evaluation. Patients are scanned and treated in head-first supine position using an arm and knee support, in free-breathing and with no abdominal compression. Respiration-correlated scans are acquired on a Philips Brilliance CT BigBore® CT-Simulator, synchronously with the respiratory signal, using a deformable rubber belt. Retrospective image reconstruction is performed for ten respiratory phases. Maximum intensity CT reconstruction and average CT reconstruction are used in treatment planning for Internal Target Volume delineation and for Organ At Risk contouring and dosimetric calculation respectively. Dose calculation is performed with a Collapsed Cone Convolution algorithm (Pinnacle 9.2) for 7 fields 3D technique and Monte Carlo dose calculation (Monaco 3.1) for intensity modulated fields. Treatments are delivered on an Elekta-Agility Linac. Patient's setup is verified with on-board Cone Beam CT (Elekta XVI).

Patients are positioned according to skin markers and the setup is verified by a radiotherapist with on-line CBCT, using the "dual registration" protocol implemented in the XVI software, where both ITV and bony anatomy are considered. Only translation errors are corrected and patients are repositioned by means of an automatic couch shift.

To quantify PTV margin we consider:

- patient's related errors: residual and intrafractional setup error (errA);

- uncertainties arising from the CBCT process: accuracy of kV- and MV-isocentre positions (errB1), accuracy and reproducibility of the image registration (errB2);
- uncertainties arising from the automatic couch repositioning (errC);
- physical uncertainties (i.e. accuracy of MV-isocentre (errD).

We analysed the collected data and separated them into the systematic (Σ) and random components (σ) in order to evaluate the PTV margin with van Herk's formula.

Results

The systematic and random component the uncertainties of the SBRT protocol are summarized in Table 1 in the anterior-posterior (AP), cranio-caudal (CC) and lateral (LL) directions.

	AP		LL		CC	
	Σ mm	σ mm	Σ mm	σ mm	Σ mm	σ mm
errA	1.7	2.2	1.4	1.4	1.1	1.7
errB1	0.30		0.30		0.01	
errB2	0.5		0.5		0.5	
errC	0.5		0.3		0.3	
errD	0.5		0.5		0.5	
Total Error	1.9	2.2	1.6	1.4	1.4	1.7

Table 1

Conclusion

We estimated an isotropic margin of 6 mm.

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Sum Signal Dosimetry: a novel approach for SBRT patient specific quality assurance

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Introduction

Stereotactic Body Radiation Therapy (SBRT), treats small neoplastic lesions to high dose with extremely steep gradients and thus requires patient-specific quality assurances (QA) with high spatial and dosimetric accuracy.

Film dosimetry with Gafchromic EBT3, while representing a widespread tool in conventional Radiotherapy QA is not able to ensure the same accuracy and sensitivity in SBRT QA, where the doses to be verified are high(>7Gy/fraction).

Aim of this work is to develop and evaluate Sum Signal(SS) Dosimetry, a novel approach able to maximize EBT3 dose response also at high doses, so allowing more accurate dose verifications for SBRT treatments.

Methods

To characterize film dose response, 3x3cm2 films were irradiated with a 6MV photon beam at different doses (range:0.2Gy-24Gy), contextually measuring doses delivered with an ionization chamber. Films were digitized before and 1 day after irradiation with Epson Expression 10000XL scanner and net optical densities(netOD) were calculated for Red Channel(RC) and Green Channel (GC).The SS is calculated by linearly summing the netOD values obtained for RC and GC:

$$SS=netOD_{RC}+netOD_{GC}$$

Dose response curves were determined for RC,GC and SS (see figure).The uncertainties were quantified using error propagation analysis.

The new SS method and the conventional Double Channel (DC) one (which uses RC for doses <10Gy and GC for higher doses) were implemented in a homemade Matlab software, in order to compare dose distributions effectively delivered by a Cyberknife system on EBT3 films to the

corresponding ones calculated by the TPS.The agreement between the two distributions was evaluated in terms of gamma analysis for 20 patients with maximum planned doses ranging from 6Gy to 25Gy

Results

Overall the SS dose-response curve is characterized by a much steeper trend, especially at doses higher than 7Gy where RC and GC curves show many contiguous signal values indistinguishable within experimental errors. Restrictive gamma test criteria of 3%/1mm exhibit 94.10% of agreement for SS and 86.79% for DC(percentage of points with g<1): the difference is statistically significant (p value=0.0027,Wilcoxon test).

Conclusions

Results obtained reveal that SS method shows higher dose accuracy in a broader dose range, overcoming the limits of DC and multichannel, which show comparable response at high doses. For this reason this method represents an efficient way to provide patient-specific QA with extreme accuracy in SBRT treatments

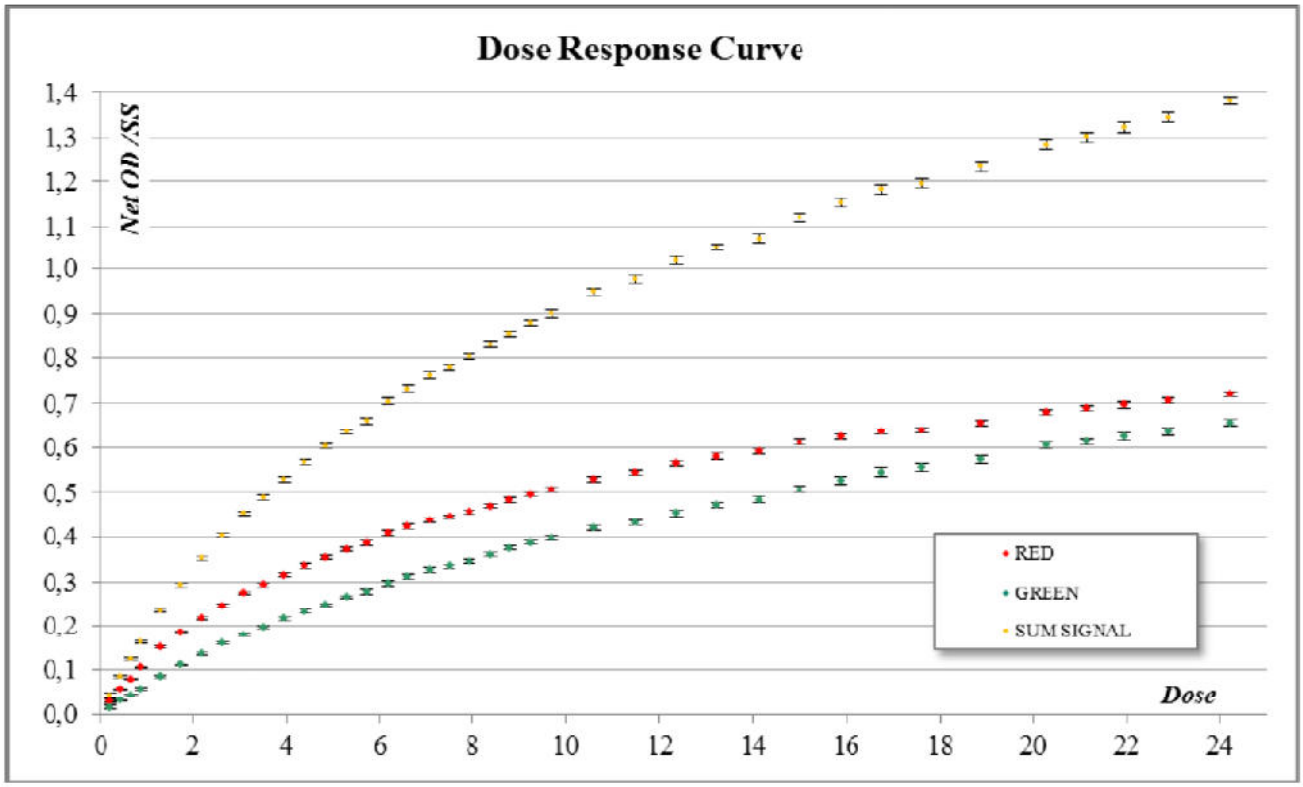

Figure 1-Dose response curve for Red Channel, Green Channel and Sum Signal.

Vincitore SBRT 2014: Analysis of intrafraction prostate motion during radiotherapy: the impact of a fast dose delivery

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**presenting author, oral presentation, Physics, Award nomination*

Introduction

In SBRT prostate treatments, a possible intrafraction motion (IFM) of the target can lead to irreversible blurring of the dose distribution as well as hot or cold spots to the target and organs at risk (interplay effect). In this study, IFM of the prostate was analysed in patients (pts) undergoing radical radiotherapy (RT) after transrectal implantation of Beacon electromagnetic transponders, in order to investigate possible treatment strategies.

Materials and Methods

By means of Calypso tracking system the coordinates of the isocenter were recorded with a 10Hz sampling frequency during full RT fractions on 10 pts. Two different motion patterns were associated to the tracking data [1]: stable target at baseline (ST) and continuous target drift (CTD). Further three types of possible prostate excursions, discernable within the treatment fractions, were investigated and classified: transient, persistent and high-frequency excursions, indicated respectively with TE, PE and HFE. For CTD cases, a linear regression was performed to correlate the overall prostate drift D to the time t spent after its localization.

Results

A total of 195 fractions out of 205 could be categorized in at least one of the two motion patterns that were previously introduced. The remaining ten cases were too irregular and difficult to categorize. Within 21 fractions, two different patterns were overlapped, both were therefore taken into account. The following pattern occurrences were observed: 116 (53.7%) ST and 100 (46.3%) CTD. Besides, it resulted the following frequency of prostate excursions: 21 (9.7%) TE, 12 (5.6%) PE and 32 (14.8%)

HFE, with a maximum value of 7.7mm, 5.9mm and 15.5mm, respectively. For CTD cases, the linear regression resulted to be $D(t) = 0.008$mm/s * $t + 0.93$mm. Assuming a reasonable time of 360s for a prostate SBRT treatment with Volumetric Modulated Arc Therapy (VMAT) (i.e. two full arcs), a mean prostate drift of 3.8mm would therefore be expected.

Conclusion

Although not directly sampled on pts treated with prostate SBRT, the reported results are of particular interest for SBRT cases where CTV_PTV margins as small as possible should be chosen to minimize the risk of toxicities. In light of the resulting frequencies and entities of prostate drifts or excursions, the use of a tracking system or, at least, a pt realignment procedure between beams (i.e. in VMAT treatments), results to be necessary for an accurate SBRT delivery.

[1] Kupelian et al, Int J Radiat Oncol Biol Phys 67: 1088-1098, 2007

Vincitore SBRT 2014: Irradiated Lung Tissues in Adaptive RT Approach: Some Criticalities

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Introduction

Stereotactic Body Radiation Therapy (SBRT) is a therapeutic option for limited stage non-small-cell lung cancer (NSCLC) and lung metastasis (LMET). In clinic the tumor motion is not ever taken into account and Gross Tumor Volume (GTV) is contoured on a free-breathing CT plan adding, sometimes, safety margins to avoid geometrical misses. Within Adaptive RT (ART) simulations it is possible to investigate the lung healthy tissues irradiated during entire cycle of treatment.

Material and methods

We have analyzed 8 patients (pts) with mean age of 76 years (66-88) with NSCLC/LMET treated at our Institute with Tomotherapy. All pts were submitted to 4-6 fractions (fx) RT regiment: 3pts received 11Gy/fx, 1pts 12.5Gy/fx, 1pts 10Gy/fx, 1pts 7Gy/fx, 1pts 5Gy/fx. Using an experimental Treatment Planning System a pre-treatment hybrid deformable registration between kilovoltage (kVCT) and daily Megavoltage Computed Tomography (MVCT) images of each patient was carried out. Hybrid deformable algorithms (grid size 0.25 cm) were performed to obtain a voxel-to-voxel matrix for volume and doses. The Regions Of Interest considered in the ART simulation were: lungs, heart, cord, ribs and GTV. All pts analyzed were submitted to follow-up at 3, 6 and 12 months from the end of RT. Pts' characteristics have been evaluate in reference to acute and late toxicities.

Results

ART methods allow us to quantify divergences from "baseline" condition and to optimize the daily plan. However during post-processed analysis some criticalities have occurred. Due to small number of slices of MVCT compared to kVCT, morphing all large areas (such as lungs and cord) it is not allowed; warping methods should be done only for the GTV. Late toxicity was found in 7 pts: G1 in

5 cases, G2 in 2. Taking into account these preliminary results, a total lung acquisition should be acquired by MVCT, but unnecessary dose to Organs At Risk (OAR) could be delivered to apply ART strategies.

Conclusions

This study is a first analysis to quantify criticalities that occur applying ART to standard SBRT cases. Acquiring entire anatomical region, using MVCT, to evaluate organ motion during RT does not seem the optimal strategy. To avoid recurrence possibilities, only a small fraction acquisition of entire lung remains preferable. Overall, to taking into account GTV shrinkage and to calculate the dose delivered at target and OAR, also anatomical motion must be accounted during each treatment session.

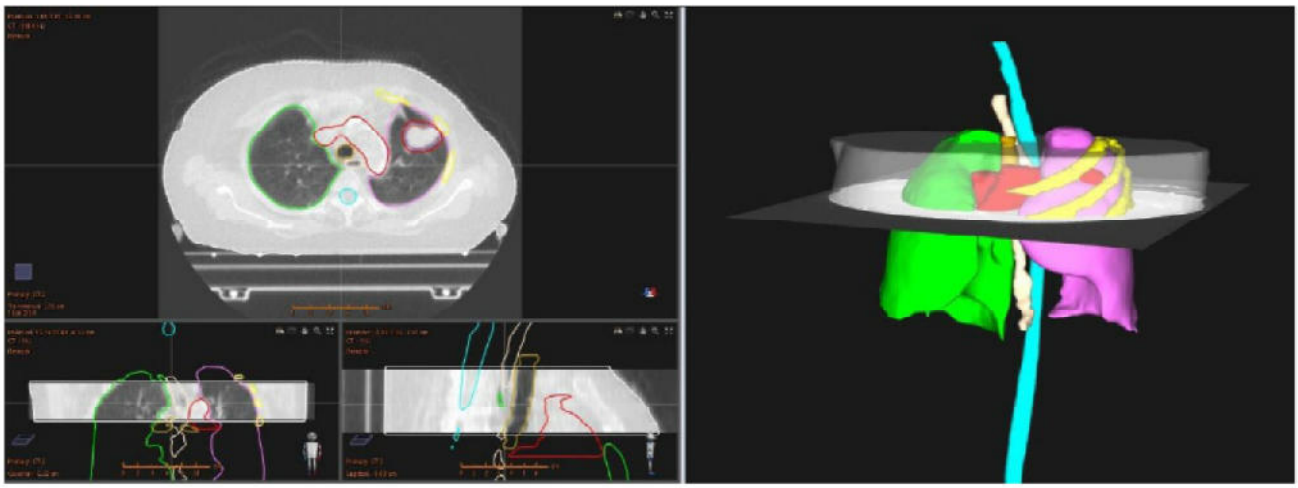

Figure 1. Axial, Sagittal and Coronal vision of a MVCT image with the contoured ROI of the initial kVCT (left). 3D reconstruction of anatomical region for the SBRT patient (right).

Acknowledges

The research is partially co-funded by the MoH (GR-2010-2318757) and Tecnologie Avanzate S.r.l.(Italy). We want to thank Dr. C. Vecchi for his precious contribution.

Adaptive Lung Sbrt : Deformable Registrations Are Clinical Applicable But Some Challenges Appear.

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Introduction

Many challenges must be solved to implement Adaptive Radiotherapy (ART) in Lung SBRT. Planning recalculation, dose accumulation, setup with limited field of view, operators time consuming are just some points. Validation of inter-fraction deformable registration (DIR) seem to be the foundation on which the entire process have to be based. This study focuses on accuracy of deformable registration for Target and Organ at Risk (OAR) and highlight challenges.

Material and methods

8 patients with lung cancer treated by Tomotherapy using SBRT were enrolled in this retrospective study. Rigid and deformable registration of pre-treatment MVCT and planning kVCT have been performed by scripting automation to optimize human resources involved in process. Accuracy of the structures obtained by DIR have been evaluated in collaboration with 4 Radiation Oncologists. A score table rating have been implemented in a Bayesian Network to assess and develop a prediction tool for automatic structure deformation and propagation. For each fraction were obtained deformed doses to evaluate and track the accumulate dose.

Results

Physicians' rate were satisfactory and above the minimum acceptability criteria (rate=6). However some structures (Lungs, Spine cord, Trachea) seemed to be more suitable than others (GTV, Ribs, Great vessels) for the deformation process. Inter-judge variability have been quantified. Bayesian analysis showed that volume variation and physicians' ratings are not statistical independent but that large variation in structure size is strictly linked to bad rating (deformable failure). First assessment

of dose accumulation showed an excellent agreement between planned and deformed doses in target, but non-negligible differences in OARs have been found (2/8 patients).

Conclusions

First approach of ART feasibility in lung SBRT have been performed with good results. Automatic DIR for target and OAR have proven reliable and robustness using python scripting. Today SBRT and DIR workflow are applicable in clinical practice. Must be highlighted some challenges (summarized in table 1) due to automation of dose accumulation and tracking.

Critical Step	Challenges	Result	Status
Deformable Registration	Limited FOV Inter-judge rate DIR time consuming	Validated	100 %
Human Resource	Scripting automation of images and structures for DIR Dose tracking and accumulation must investigated	Optimized	90 %
Dose Accumulation	Discrepancy due to inter-judge of objects deformed and propagated Limits due to different image quality and FOV limitation	First step	40 %
Dose Tracking	Available only for LINAC but not for Tomotherapy Not applicable in case of multiple lesions, re-treatments or recurrence	WIP	10 %

Table 1 Challenges in Stereo Body Adaptive Radiation Therapy

Acknowledges

The research is partially co-funded by the MoH (GR-2010-2318757) and Tecnologie Avanzate S.r.l.(Italy). We want to thank Dr.C.Vecchi for his precious contribution.

SBRT pre-treatments QA: two different approaches.

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Introduction

Stereotactic body radiation therapy (SBRT) requires a more comprehensive quality assurance (QA) program than 3DCRT and IMRT (or VMAT), especially because of its very high-dose gradients.

The purpose of this study is to test a IBA 3D dosimetry analysis package, COMPASS 3.0 with MatriXX*Evolution* ion chamber array, for SBRT pre treatment verification in terms of 3D dose, gamma analysis, Target and OAR structures DVH.

Materials and Methods

Nine SBRT treatments with different dose fractionations have been selected: 3 brain cases (2 cases of 21Gy x 1 and one of 15Gy x 1), 3 liver cases (15Gy x 3) and 3 lung cases (2 cases of 15 Gy x 3 and one of 8 Gy x 4).

All measurements, performed with COMPASS, were compared with the reference dose distributions calculated in Eclipse TPS using AAA 10.0.28. The same cases were analyzed with our pre treatment verification system (used routinely), based on EPID images and EPIQA software.

For the evaluation of pre-treatment verification agreement, differences in $D_{99\%}$, D_{Mean} and $D_{1\%}$ were investigated and local γ analysis (3mm/3%) has been performed for PTV structures.

We have also compared the calculated dose plan from Eclipse TPS with computed dose by COMPASS as an independent secondary TPS.

Results

Tab.1 shows maximum differences between Eclipse TPS and COMPASS measurements in terms of $D_{99\%}$, $D_{1\%}$ and D_{Mean}.

		Max Dose Difference Eclipse/ Compass Measurements		
		$D_{99\%}$	D_{Mean}	$D_{1\%}$
LUNG	PTV	3,1%	1,7%	4,2 %
	CTV	4,0 %	3,1%	1,8 %
BRAIN	PTV	3,4%	1,1%	2,1%
	CTV	1,3%	1,3%	2%
LIVER	PTV	1,7%	1,9%.	2,1 %
	CTV	2%	1,4 %	1%

Tab. 1

For liver and brain cases local γ analysis with COMPASS shows for PTV, in the worst scenario, a number of point with $\gamma<1$ of 96,5 % and 97,3 % respectively.

Local γ test fails for PTV and CTV (86,5 % and 82 %) only for one of lung cases; this failure derives from a difference of +4% in absolute dose inside the CTV. Even if this result could be not acceptable with conventional pre-treatment verification devices, the chance to investigate about dose differences inside the target and OAR, could be really interesting from a clinical point of view to approve plans delivery.

With EPIQA the worst scenario consists in a number of points with $\gamma<1$ of 96,68 %, 98,11% and 96% for brain, liver and lung cases respectively. Computed plans with COMPASS are well correlated to the reference values of Eclipse.

Conclusion

All treatment cases result acceptable with the two studied approaches both from the dosimetric and clinical point of view. Compass dose reconstruction gives very interesting information about 3D dose distribution taking into account patients anatomy.

Preliminary study about SBRT on prostate using MV images and fiducial markers

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Introduction

Stereotactic body radiation therapy (SBRT) is the result of technological advances in patient immobilization, image guidance, treatment planning and delivery. Emerging data show the safety and efficacy of this treatment modality in prostate cancer.

Patient position during radiotherapy treatment of prostate cancer can be verified with the support of various solutions as Cone Beam CT or KV/MV portal images, acquired before or during treatment based on the bony anatomy.

The aim of this study is to perform a preliminary analysisabout potential benefit of fiducial markers for inter-fraction organ motion correction using planar MV images for prostate SBRT treatment.

Materials and Methods

We analysed portal images from each treatment fraction of a conventional prostate treatment; for organ position verification cylindrical gold markers (10mm length and 0.75mm diameter) were implanted before starting radiotherapy.

Portal images, obtained by Portal VisionTM aS1000(Varian Medical System) have been acquired at 30° and 350° and were matched with DRR using the implanted gold markers. These results were compared with matching obtained with bone landmarks, normally used for patient positioning. Finally we evaluated the worst scenario introducing the maximum shift(obtained from the evaluated differences) in our Eclipse TPS system recalculating the original plan.

Results

The average shifts difference between gold fiducial markers and bony anatomy are found to be (0,46±0,59) mm in Antero-Posterior (AP)direction, (1,09±0,92) mm in Cranio-Caudal (CC) direction and (0,59 ±0,73) mm in Latero-Lateral (LL) direction. Fig.1 shows patient shift differences using fiducial markers respect to bony anatomy.

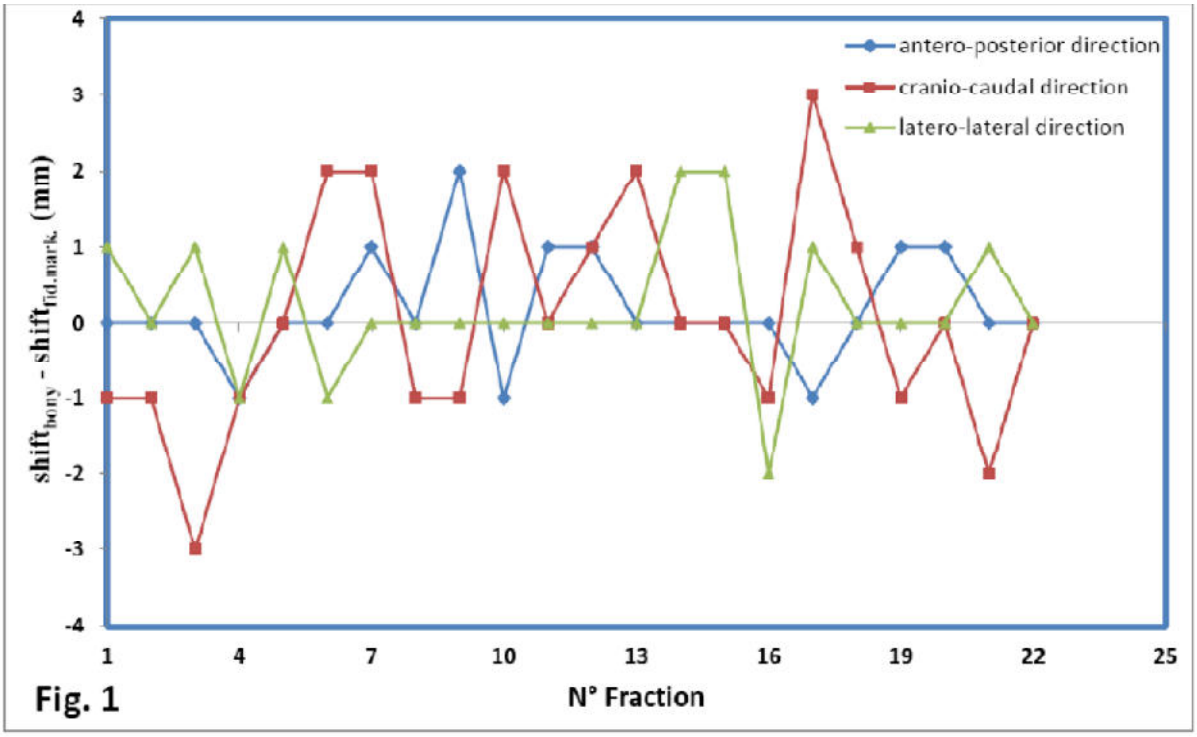

Fig. 1

In the reference plan D98%=91,55%, and considering the worst scenario with a shift in isocenter position of -1mm AP, 3mm CC and 1mm LL,D98%=83%.No relevant change is present in CTV coverage.

Conclusion

Even if differences between two methods, for conformal treatment and standard fractionation, could be not significant, in a SBRT scenario they acquire more importance leading to a potentially undercoverage of the target.Gold fiducial markers seems to be an accurate and precise tool for pre-treatment patient position verificationin SBRT using MV images. However it's necessary to have much more several data to refine some details such as the angle acquisition of portal images and the best fiducialmarkers's size and number.

A LEGO Mindstorms Biomechanical Phantom To Simulate Breathing Motion

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Introduction

The lack of knowledge of the exact position of Region of Interest and tumor increases uncertainly during the contouring, planning and delivery of Radiation Therapy (RT) treatments. During Stereotactic Body RT (SBRT), breathing motion is an issue that cannot be precisely determinate using Computed Tomography (CT) study. In four-dimensional CT (4DCT) gating/tracking systems can reconstruct patient's respiratory phases. Understand internal organ motion it remains however fundamental. In this study an anthropomorphic phantom was built using LEGO Mindstorms to simulate real patients breathing and internal motion in the lung district.

Material and methods

The phantom has pediatric dimension and was built using LEGO Mindstorms adding to the Core Set an Expansion Set. A system of mechanical gears allows the simulation of 8 ribs and 2 tumors with simultaneously and independent motion at different angular velocities. The gears and robotic parts are made of plastic material to avoid CT images artifacts, of some commercial phantoms. The 2 artificial tumor masses with 4 degree of freedom take places in the thoracic cavity. The breathing rate is obtained by a InfraRed/UltraSound sensor through a real-time observation of patients breathing sinogram reproduced by Quasar phantom. The intelligent brick is equipped with a LINUX OS LABView fully programmable.

Results

The breaths of 4 patients have been acquired in a 4DTAC study by a VisionRT system. From the CT exams a Gross Tumor Volume center of mass was defined as tumor position and followed during breathing phases. The 3D tumor motion was calculated from patients motion coordinates. The 4D

function obtained has been simulated by the phantom tumor masses. A new 4DCT is been investigated to reproduce the 4D patient sinogram in real-time by phantom. Markers and ion chamber, inside ribs and tumors of the LEGO phantom, have allowed to follow and to track process of organ motion and dose within the same image.

Conclusions

This research is a first biomechanical approach to evaluate breath and motion using an humanoid robot. Internal-external correlation using surrogate signal and device is feasible and available. The creation of realistic models of organ motion allows to quantify divergences due to internal warping and allows to predict real-time tumor position and dose delivered during the treatment delivery. LEGO phantom makes Quality Assurance of Adaptive RT methods usable in daily clinical practice.

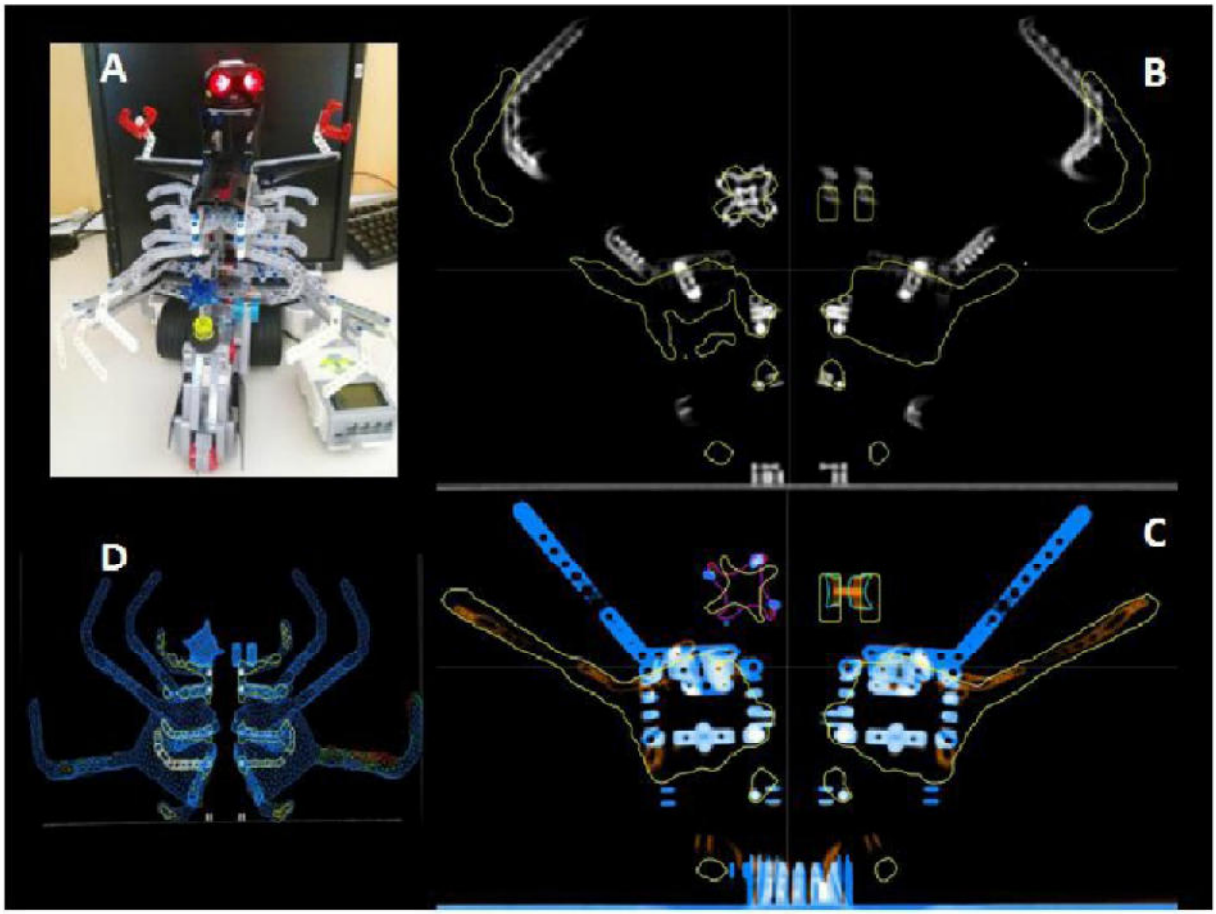

Figure 1. (A) The LEGO Mindstorms phantom. **(B)** 4DTAC with initial contours of ribs and tumors. **(C)** 4DCT study with maximum inspirum (orange) and expirium (blue). **(D)** 3D mesh grid reconstruction of LEGO phantom ribs and GTV.

Acknowledges

The research is partially co-funded by the MoH (GR-2010-2318757) and Tecnologie Avanzate S.r.l.(Italy). We want to thank Dr. C. Vecchi for his precious contribution.

Configuration of a Treatment Planning System: study and dosimetric evaluation for stereotactic treatments with small fields.

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Purpose

Stereotactic radiotherapy and radiosurgery is increasingly used mostly due to the availability of advanced and robust planning techniques. This growth has inevitably led to an increase in use of small fields (5-40 mm), not only for small volumes interested in these therapies, but also because high conformation is reached through a high modulation of the entire radiation field. Problems related to the study of small fields is not only connected to the accuracy of measurements but also to their modeling. From a modeling point of view, the main problem is that the photon source (that has finite size and is not a point source) might not be fully visible from the point of measurement, because partially occluded by the collimating system. This has a strong impact on field size and radiation output.

Aim of this work was to evaluate the accuracy of a dose calculation algorithm implemented in a TPS currently in use and the essential parameters used by TPS to calculate dose and monitor units. This was finalized to assess critical factors that affect TPS and to have an indication on how to perform beam commissioning of a clinical algorithm focused on the planning with small fields.

Methods

Eclipse, AAA.11.0.30 (Varian Medical Systems) was studied. To evaluate the TPS accuracy for small fields used in stereotactic treatments a comparison between TPS calculation and experimental measures was performed. Profiles and output factors (OF) were measured in water with a microdiamond detector. Investigated jaw-collimated open fields were: 10x10; 8x8; 6x6; 5x5; 4x4; 3x3; 2x2; 1x1; 0.8x0.8 and 0.6x0.6 cm^2 with 6MV, 6FFF and 10FFF photon beam generated by a TrueBeam STX (Varian). TPS accuracy was evaluated for different measured OF values and for different spot size values (1; 0.8; 0.5; 0 mm) included in the beam data. All this study was repeated for MLC shaped open fields up to 0.5x0.5cm^2. Five RA test plans were optimized and calculated in

every different TPS configuration and compared with the relative delivered dose distribution using Gamma analysis.

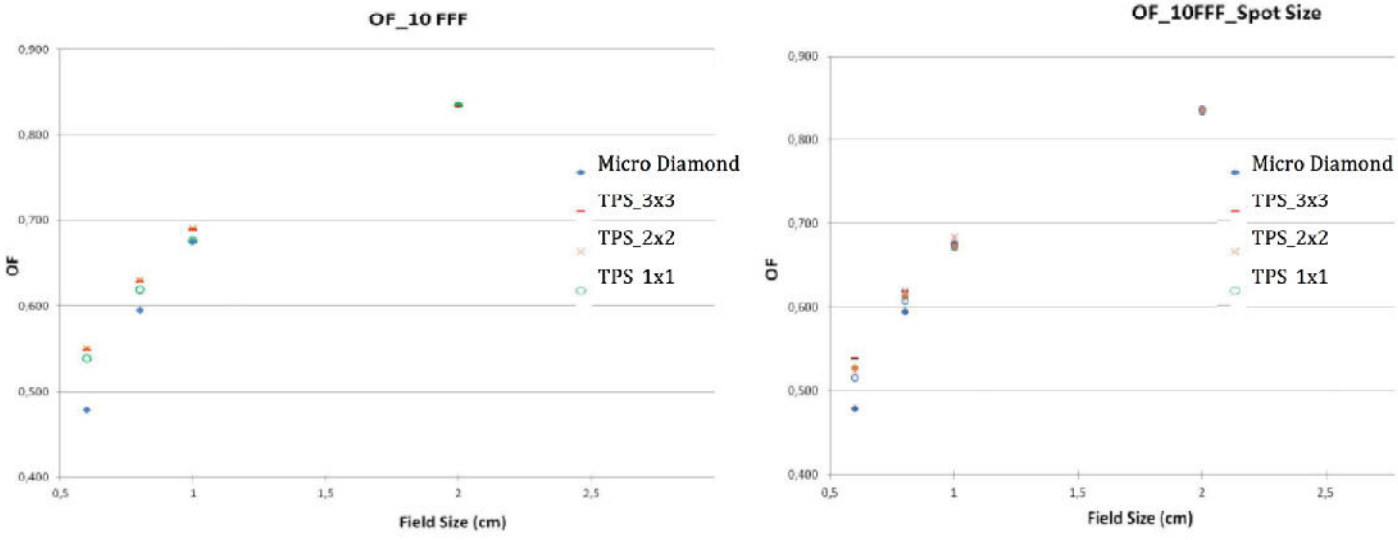
Results

Experimental measurements of OF fields smaller than 3x3 cm^2 has a strong impact on accuracy of MU calculation for small fields: addition of OF up to 1x1 cm^2 (smaller field available in beam configuration) led to a better agreement between measured and calculated values, up to 0.6x0.6 cm^2 calculated field. This result suggest to investigate the feasibility of insert fields smaller than 1x1 cm^2 in beam configuration. The primary source size parameter (spot size) included in beam configuration affects all calculated data for small fields (both OF and profiles). Value of 0 mm (the one recommended by default) was proved to be not the most appropriate: measurements shown that a value between 0.5 and 0.8 mm improves the accuracy of TPS calculation. Study of MLC shaped fields shows a difference between calculated and experimental values: no TPS configuration reduces these discrepancies. It seems to be necessary to improve MLC modeling and parameters in TPS in order to better describe measured data.

Dose calculated for RapidArc stereotactic plans showed an acceptable agreement between delivered and planned dose for every TPS configuration.

Conclusions

Eclipse AAA.11.0.30 showed acceptable characteristics for stereotactic small fields. From the data presented it was shown that a adequate tuning of the studied configuration parameters in the treatment planning system is strongly suggested for the accuracy of plan calculation with small fields used for stereotactic treatments.



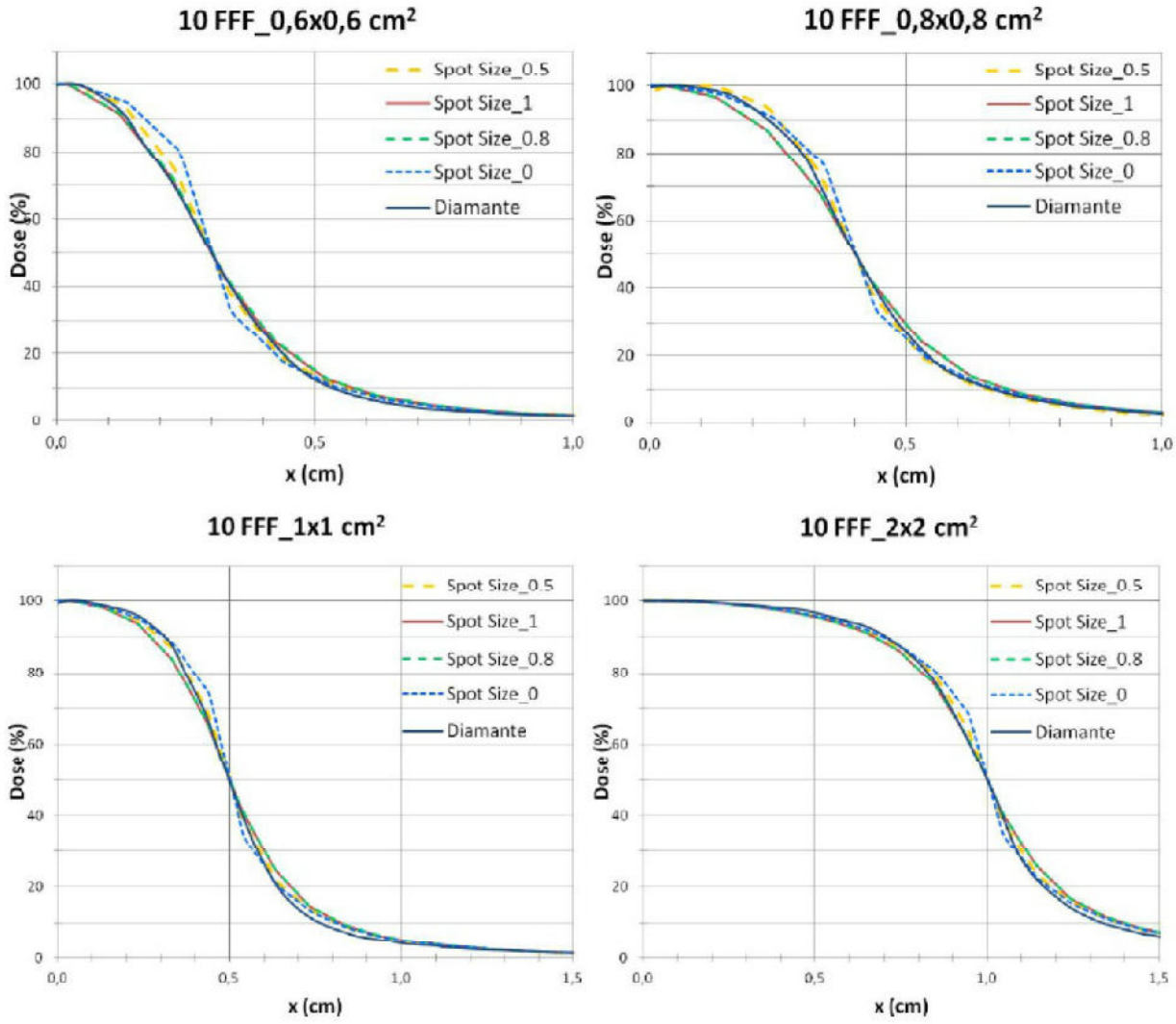


Figure 1: Comparisons between measured and calculated OF and profiles for the 0.6x0.6, 0.8x0.8 1x1 and 2x2 cm^2 fields for the 10FFF beam. Figures shows measured OF and profiles compared to the calculated ones for different OF values and spot size parameters included into TPS configuration.

Commissioning of an Elekta Versa HD linac with flattening filter-free beam technology

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Aim of the study

This work presents the commissioning of a Versa HDTM linear accelerator (Elekta AB) at the "Pugliese-Ciaccio" Hospital in Catanzaro, Italy. In the High Dose Rate Mode the linac operates with high energy flattening filter-free (FFF) photon beams of 6MV and 10MV.

Materials and Methods

The Versa HDTM linac is equipped with two high energy photon beams with flattening filter (6 and 10 MV FF) and two high energy flattening filter-free photon beams (6 and 10 MV FFF). The linac is equipped with the Agility dynamic MLC composed of 160 leaves with 5mm width at isocentre. The measurements were performed with an IBA Blue Phantom2 and Omni-Pro Accept 7 software. For radiation fields in the range 40x40 cm2 to 4x4 cm2 a Scanditronix-Wellhofer CC13 ionisation chamber with a 0,13 cc volume was used, while a Scanditronix-Wellhofer CC04 ionisation chamber with a 0,04cc volume was used in the range 5x5 cm2 to 1x1 cm2. A Dose1 electrometer was used for absolute dose dosimetry. The measurements were performed according to the IAEA TRS-398 protocol.

The measurements were performed with the linac operating in the High Dose Rate Mode, with a dose rate of 1300MU/min and 2200MU/min for the 6MV FFF and 10MV FFF beams respectively. Preliminary measurements were performed in order to verify the IC linearity with dose rate for both relative and absolute dosimetry. Inplane and cross plane profiles were measured at SSD = 90 cm for 2x2, 3x3, 5x5, 10x10, 15x15, 20x20, 30x30 and 40x40 cm^2 open fields at the depths of dmax, 5, 10 and 20 cm. Percentage Depth Dose (PDD) profiles were measured for 1x1, 2x2, 3x3, 4x4, 5x5, 7x7, 10x10, 15x15, 20x20, 30x30 and 40x40 cm^2 open fields.

Results

Profiles of flattening-filter free beams have a different aspect than a flattening filter beam. In figure 1 crossplane profiles for a 6MV FFF beam for field sizes from 40x40 to 2x2 are shown. The profiles are normalized to the centre of the beam.

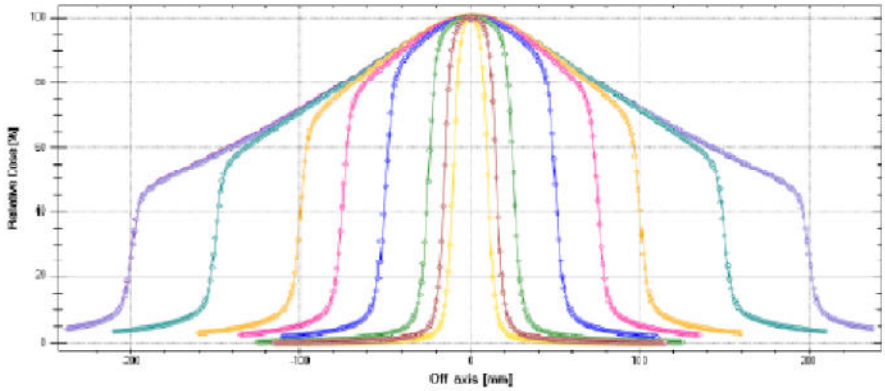

Figure 1. 6MV FFF crossplane profiles for field sizes from 40x40 to 2x2

The field dimensions for FFF beams cannot be defined in terms of FWHM as the relative dose at the nominal field edge changes in terms of field size, as shown in table 1.

Field	40x40	30x30	20x20	15x15	10x10	5x5	3x3	2x2
6MV FFF	27,4	33,5	38,9	43,5	47,4	51,50	53,5	52,1
10MV FFF	23,5	27,6	33,6	39,1	44,7	50,30	53,3	52,1

Table 1. Percentage dose value at nominal field edge position for various field sizes.

While the FFF profiles are significantly different than FF beam profiles for large field sizes (figure 2), this difference diminishes as the field size decreases.

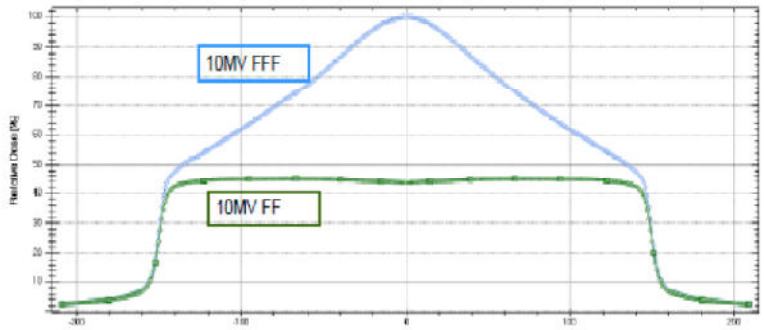

Figure 2. Crossplane profiles for a 30x30 field for 10MV FF and 10 MV

For field sizes 5x5 and below the percentage difference between a FFF and a FF profile is less than 5% for both energies, as shown in figure 3.

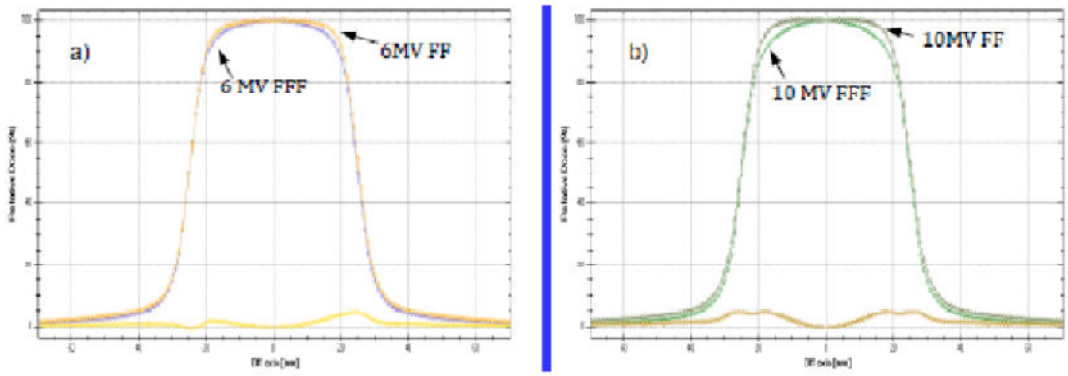

Figure 3 Crossplane profiles for 5x5 field for a) 6MV FF and 6MV FFF and their difference, b) 10 MV FF and 10 MV FFF and their difference.

The PDDs for the FFF beams differ from the FF beams as the field size increases, as shown in figure 4. For example, the Quality index (D200/D100) for the field sizes shown in figure 4 are for the 5x5 field 0,59 and 0,58, for the 10x10 field 0,61 and 0,60, and for the 40x40 field 0,66 and 0,63 for the 10MV FF and 10 MV FFF beams respectively.

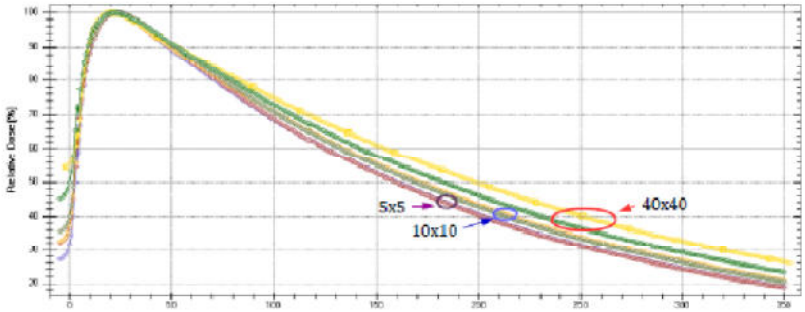

Figure 4. PDD for 5x5, 10x10 and 40x40 fields for 10MV FF and 10MV FFF beams.

Conclusion

In terms of in- and cross-plane profiles and PDDs the FFF beams are comparable to FF beams for small fields but not for larger field sizes. Further studies are however necessary in order to investigate the clinical use of FFF beams compared to FF beams for different treatment techniques.