Breast Radiotherapy in 2019, challenges & solutions
Wednesday 10th April, London

PROGRAMME

09:15 – 09:55  Coffee and registration
09:55 – 10:00  Introduction
10:00 – 10:45  Invited talk: Breast Radiotherapy in 2019, challenges & solutions
               Dr Richard Simcock, Brighton and Sussex University Hospitals NHS Trust
10:45 – 11:15  Three-field breast planning study
11:15 – 11:45  Coffee
11.45 – 12.00  Experiences of a Breast Consultant Radiographer – the story so far…
               Emma Thompson, The James Cook University Hospital. Middlesbrough.
12.00 – 12.15  Automated tangential breast and boost treatment planning using Raystation
               Neil Richmond, Newcastle upon Tyne NHS Foundation Trust
12.15 – 12.30  Automating Breast Planning: Philips Pinnacle TPS Scripting
               J Flaherty, Singleton Hospital, Swansea
12.30 – 12.45  Enhanced nodal coverage and conformity of dose in breast and supraclavicular fossa irradiation
               Helen Curtis, The James Cook University Hospital
12.45 – 13.00  Moving breast treatments from a conventional C-arm linac to a Halcyon
               A Seegobin, Queen’s Hospital, Romford
13.00 – 14.00  Lunch
14.00 – 14.15  The development of a device to immobilise the breast during radiotherapy: The SuPPORT 4 All project.
               Heidi Probst, Sheffield Hallam University.
14.15 – 14.30  A breast imaging study to determine the efficacy of 3D kV-kV planar image matching for validating set-up of breast treatments.
               Aisling Haughey, North West Cancer Centre, Northern Ireland
               Helen Clough, Leeds Teaching Hospital NHS Trust, UK.
               Wendy Hyland, North West Cancer Centre, N. Ireland
15.00 – 15.30  Coffee
15.30 – 15.45  Derby experience of treating high risk breast patients (involving IMC) with Rapid Arc
               Victoria Malysh-Smith, Royal Derby Hospital, Derby UK.
15.45 – 16.00  Development of optimal treatment techniques for breast patients requiring IMC irradiation
               Paul Clarke, Oxford University Hospitals NHS Foundation Trust
16.00 – 16.15  A 2-year evolution of IMC treatment using VMAT, DIBH and online IGRT
               Aileen Considine, Peterborough City Hospital, North West Anglia NHS Trust
16.15 – 16.30  Discussion and close

Organised by IPEM’s Radiotherapy Special Interest Group
Programme subject to change
A four-tier career structure was published by the College of Radiographers in 2000, outlining an advance from assistant practitioner to radiographers, advanced practitioners through to consultant radiographers. The ethos was to develop radiographer roles to provide high quality patient centred care, and in doing so provide opportunities for career progression, leading to recruitment and retention of staff. This structure was piloted successfully in the breast screening service with diagnostic radiographers. In radiotherapy many radiographers developed skills as advanced practitioners in treatment review, image interpretation and treatment planning, taking on tasks historically completed by a consultant oncologist or registrar. The role of the Consultant Radiographer (CR) takes this delegation of tasks further and has been a role that many departments have been slower to adopt. A CR will typically have their own patient workload with additional responsibilities for leadership, education and research. Radiotherapy of breast cancer makes up for 20-30% of a typical department’s workload. Many patients see a Medical Oncologist who is responsible for their systemic therapy and overall cancer care, seeing a Clinical Oncologist solely to discuss, consent for and deliver radiotherapy. It was identified that this role could be efficiently carried out by a non-medical practitioner i.e. a consultant radiographer. Patient with early breast cancer referred for adjuvant radiotherapy after surgery could similarly be referred with the responsibility for overall clinical care being carried out by the surgical team. These treatment pathways formed the foundations of a business case for a CR in breast radiotherapy at the James Cook University Hospital.

For this talk I would like to describe the remit of my role and my experiences in the six months I have been in post and how this has impacted on the multi-disciplinary team.
Automated tangential breast and boost treatment planning using Raystation
Wilkinson M, Richmond N and Dixon B
Northern Centre for Cancer Care, Newcastle upon Tyne NHS Foundation Trust, Freeman Hospital, Newcastle upon Tyne, NE7 7DN

Background
NCCC serves a patient population of 2 million, with approximately 100 patients referred for breast radiotherapy monthly. Our previous workflow for breast treatments involved field placement on ProSoma by trained dosimetrists using Casebow’s formulae. Automatically generated breast volumes, from field borders and outlined structures (skin, lung and heart) assist in the generation of a forward planned IMRT plan optimised on Oncentra Masterplan TPS. The complete process taking approximately 1.5 hours per patient. Where photon boost treatments were indicated, they were forward planned using a three wedged field technique also on Oncentra. The RayStation (TPS), was commissioned for clinical use in July 2016. It has an integrated automated breast planning module and scripting tools which promised to dramatically reduce planning times. We therefore decided to revise our current technique and investigate using Raystation to streamline the pathway, reduce planning times and produce inverse planned SMLC IMRT tangential field and VMAT photon boost plans.

Method
The Raystation Auto-Breast process involves markers placed on the patient’s skin surface at CT being detected by the software to determine field extent, automatic definition of OARs and CTV, prior to an optimised tangential field IMRT plan being generated. Disadvantages of using this module however are that the prescription, clinical goals and optimisation objectives are fixed by the vendor, the superior field border is divergent and optimised segments have MLCs that extend beyond the back edge. We amended the Auto-Breast process workflow via the scripting interface provided by Raysearch and simplified the process further enabling customisation of the technique in accordance with our intended streamlined departmental workflow. Prompts were added allowing dosimetrists to choose from a range of planning options, and all plan labelling is standardised. A further script was produced to automatically create an optimised VMAT boost plan once a boost CTV had been defined.

Results
NCCC are the first UK users to implement the Raystation Auto-Breast planning module, with planning times of less than 5 minutes being achieved from data import to a fully optimised tangential field IMRT plan. Furthermore, an optimised VMAT boost plan can be generated within 3 minutes after CTV outlining using the locally written script. The patient pathway through the planning process has been condensed as planning times have been dramatically reduced. A further benefit of the new planning techniques has been the rendering of wedge use in the department obsolete cutting the physics quality assurance burden. In comparison with Oncentra, Auto-Breast plans generally have reduced dose contributions from higher energy beams (15MV) and all clinical goals are met; target coverage has been improved and lower Lung V12 and Heart V10 doses have been achieved.

Conclusion
The Raystation Auto-Breast module has been successfully implemented for Breast only planning together with scripting for photon VMAT boost planning. Planning times have been reduced and plan quality improved.

References

Automating Breast Planning: Philips Pinnacle TPS Scripting
Flaherty J, Etheridge D, Williams J.
Department of Medical Physics & Clinical Engineering, Singleton Hospital, Swansea, UK.

Background – Current clinical practice for breast/chest wall radiotherapy uses a forward-planned Field-in-Field technique (using Oncentra MasterPlan) based upon breast target localisation set by Specialist Radiographers applying medial/lateral tangential fields in Virtual Simulation software (Prosoma). As part of the Fast Forward trial the department developed Prosoma scripts to generate whole breast/chest wall PTVs based upon the applied fields and OAR structures, but the planning stage was still manual. Breast/chest wall PTVs and heart and lung outlines are not routinely created unless clinically requested due to the extra workload.

We are in the process of transitioning breast planning to Philips’ Pinnacle TPS. The availability of scripting within the planning software and previous experience with scripts will allow the shift to inverse plan these breast ‘mini/boost’ fields, and increase general efficiency and consistency via automation through scripting.

Methods - For breast planning, we have developed initial planning scripts within Pinnacle. These perform various operations, such as referencing the plan, but also include:
1. Weighting both main tangential fields to achieve an initial balanced dose distribution
2. Generating of a PTVwb routinely, from the main tangential fields using the calculated 50% isodose, restricting 5mm off the patient external, field edges (10mm superiorly and inferiorly), and organs at risk (ipsilateral Lung, and if left sided, Heart) as per FAST-Forward guidelines.
3. Duplicating main medial and lateral tangential fields, and setting these copies as ‘Step & Shoot MLC’ type beams.
4. Creating two dose prescriptions, one for main tangentials (~80% of dose prescription) and the other for mini tangentials (~20% of dose prescription).
5. Setting IMRT parameters (e.g. max iterations, maximum number of segments, minimum segment MU, minimum segment area etc).
6. Launching optimisation loops (no optimisation on main fields, but DMPO on mini fields, with max jaw size limited to those of the main fields) – first of which will optimise on the PTVwb uniform and min dose, then following the result of this, the second optimisation loop, if certain ‘hotter’ isodoses are present, will create an ROI from this, and optimise it’s max dose.

Results – Initial results show equivalent or superior dose homogeneity and minimum coverage of PTVwb with equivalent or lower OAR doses (Ipsilateral Lung and, if left sided Heart) when compared to OMP plans – at the expense of increased number of segments and MU from the ‘mini’ fields.

Discussion & Conclusion – Scripted plans are of comparable or better clinical quality than manual plans. Further development of robustness and reduced MU from the ‘mini’ fields is needed before clinical use for all breast patients. Fine tuning per-patient, potentially by relating patient size (PTVwb volume, or breast height and separation) to the maximum number of segments required, photon energy utilised or dose prescription split will also be investigated.

Key references – FAST-Forward trial planning pack version 3 (2013)
Enhanced nodal coverage and conformity of dose in breast and supraclavicular fossa irradiation

Curtis H, Storey N, Sethugavalar B, Burke K, Daniel J, Brand J

Department of Medical Physics and Directorate of Radiotherapy and Oncology, The James Cook University Hospital, Middlesbrough, UK

Background: Treatment of breast and supraclavicular fossa (SCF) nodes at our centre use fields which are geometrically determined and constructed in a virtual simulator (Prosoma v4.1, Medcom) using CT data. Plans are prepared using Oncenstra MasterPlan (v4.3, Elekta) and dose is calculated using the collapsed cone algorithm. Tangential fields employ wedge and field in field (FiF) techniques as appropriate to comply with ICRU hotspot guidance. An anterior SCF field is prescribed to $d_{\text{max}}$ matched where indicated. To improve homogeneity and conformity of breast and nodal volumes, a dynamic MLC (dMLC), inverse planning technique was commissioned using a Monte-Carlo algorithm in Monaco (v5.11, Elekta) to include both the breast and lymph node target volumes.

Methods: Data from 15 patients (10 left and five right sided) treated for breast and SCF tumours was used for a retrospective planning study. A breast planning target volume (PTV) based on field-placed beam intersections and excluding OARS, consistent with the IMPORT HIGH trial, was generated by a ProSoma script. Lymph node (LN) clinical target volumes (LNCTVs) were outlined enabling LNPTVs to be created using ESTRO consensus guidelines. Monaco was used to develop a planning class solution involving an inverse planned optimised dMLC delivery sequence with tangential beams covering the breast PTV and two anterior oblique beams covering LNPTV. The planning solution is mono-isocentric with no match-plane border and has enhanced beam positioning at the individual PTV junctions to optimise dose in this region.

Results: Plans had combined PTV coverage which conformed to dose homogeneity criteria given in the IMPORT HIGH trial protocol. Dose conformity and homogeneity compared favourably to wedge, FiF plans. LNPTVs had greater dose volume coverage compared to single anterior field placed beams. OAR doses were comparable to OMP plans. Delta4 (ScandiDos) delivery of plans produced acceptable gamma comparison results (>98% at 2%/3mm pass criteria).

Table of results:

<table>
<thead>
<tr>
<th></th>
<th>Patient 1</th>
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<th>Patient 3</th>
<th>Average of all patients</th>
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</thead>
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<td>dMLC Monaco</td>
<td>Wedged OMP</td>
<td>dMLC Monaco</td>
<td>Wedged OMP</td>
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<tr>
<td>Breast PTV V95% (&gt;90%)</td>
<td>97.0</td>
<td>96.7</td>
<td>96.4</td>
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<tr>
<td>LN PTV V95% (&gt;90%)</td>
<td>93.5</td>
<td>76.0</td>
<td>94.3</td>
<td>83.1</td>
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<td>0.11</td>
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<tr>
<td>Homogeneity Index (HI) LN PTV</td>
<td>0.13</td>
<td>0.19</td>
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</tr>
<tr>
<td>Ipsilateral Lung V30% (%)</td>
<td>33.3</td>
<td>40.0</td>
<td>38.1</td>
<td>39.0</td>
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</tbody>
</table>

Conclusion: A class solution for breast and SCF treatments using a dMLC technique has been commissioned using Monaco v5.11. Superior dose conformity, homogeneity and nodal coverage is seen compared to field based OMP plans. Introduction of this new technique for all breast and SCF patients is expected within a year.

Key References

1 IMPORT HIGH, Cancer Research UK, CRUK/06/003
2 Offersen et al, Radiother Oncol. 2015, 114(1): 3-10
Moving breast treatments from a conventional C-arm linac to a Halcyon

1Seegobin A, 1Borchardt E, 2Withers D
1Radiotherapy, Queen's Hospital, Romford, UK
2Radiotherapy Physics, Queen's Hospital, Romford, UK

Background
The Radiotherapy department recently went through an equipment refresh programme replacing three Varian Clinac iX linacs with an Edge linac (HD MLC, 6MV, 6FFF, 10MV, 10FFF and electrons) and two Halcyon 2.0 linacs. The Halcyon has a single 6MVFFF energy and is an enclosed ring-gantry-based linac, with a 100cm-wide bore in which the patient is positioned and treated. The Halcyon has MV imaging at 0 and 90 degrees, kV CBCT but no planar kV imaging, no light field, no optical distance indicator, and currently no gating is available. Approximately 35% of the department’s patients are treated for breast cancer, requiring at least some cases to be treated on Halcyons; this started once the second Halcyon was in clinical use in October 2018. The breast treatment technique used on conventional linacs was adapted for Halcyon to accommodate these differences (initially for two-field non-DIBH only).

Methods
The department’s standard conventional breast technique for conventional linacs is optimised IMRT (sliding-window) tangential fields. Treatment radiographers and dosimetry staff worked together to determine the effects on planning and treatment of the physical limits of Halcyon use, i.e. couch and patient position in the bore, extent of field size, and kV-CBCT imaging size.

Results
Changes from the existing planning and treatment techniques were minimised as much as possible. The main change in planning was that the isocentre was placed midline to avoid collisions with the bore. Dosimetry of Halcyon breast plans was comparable with that from conventional linacs and accepted by clinical oncologists. Halcyon workflow requires imaging before every treatment, therefore daily kV-CBCT images are obtained whereas our conventional linac techniques use kV planar and MV planar images (not necessarily daily) to determine position. Field borders on CBCT slices and field edges on CBCT DRRs assist in alignment. On the Halcyon the patient is aligned to tattoos, moved into the bore, a kV-CBCT is obtained, soft tissue matching carried out and moves are made if necessary before treatment. Fast CBCT acquisition (16.6s), 4rev/min gantry speed between fields, and FFF doserate allow for short treatment times, typically 8 minutes from walking into the bunker to walking out.

Discussion
Moving two-field non-DIBH breasts to Halcyon has gone smoothly. There have been no issues so far that have required a change in the process developed for Halcyon. The biggest change compared with our conventional linac breast technique is imaging. The Halcyon’s maximum kV CBCT length of 24.5cm allows for the whole breast to be imaged; the Breast CBCT mode on Halcyon has the lowest DLP (13.5 mGy*cm) of all available modes.

Conclusion
A two-field IMRT non-DIBH breast treatment was successfully implemented on Halcyon. Further work will involve developing a three-field technique (i.e. including SCF) and simultaneous integrated boost technique, and looking at further reducing the DLP of breast CBCTs.

Key references. Breast, FFF, Halcyon, IMRT
The development of a device to immobilise the breast during radiotherapy: The SuPPORT 4 All project.
1 Probst H, 1 Reed H, 1 Stanton A, 1 Rosbottom K, 1 Crank H, 2 Bryan-Jones K, 1 Sheffield Hallam University. 2 Sheffield teaching Hospitals NHS Foundation Trust.

Background. Breast cancer is a global problem1. Survival rates following local excision and radiotherapy are good (79-98% at 4-5 years). With local recurrence generally low (0.3-10%)2 more women are living with the side effects of therapy, with survival projected to reach 1.7 million by 20403. Hence, it is important that radiotherapy for breast cancer is optimised to reduce long term side effects that may impair quality of life during survivorship.

New radiotherapy techniques may allow sparing of sensitive organs such as the lung and heart; but these require high precision to avoid undesirable outcomes4,5. Women with larger breasts often report worse skin reactions, and this maybe a function of the volume of skin receiving 80% of the target dose6; skin toxicity is often worse in the inframammary fold where there may be a loss of skin sparing. Furthermore, women lie naked from the waist upwards when many are adjusting to an altered body image. An immobilisation prototype has been designed to improve radiotherapy accuracy, reduce potential dose to organs at risk (in women with larger breasts), improve skin toxicity for women with larger breasts and improve patient modesty.

The aim of the study was to refine, produce and test a support bra for immobilising breast tissue during radiotherapy (for women referred with an intact breast). The primary endpoint was a support bra that is technically acceptable to health-care professionals (HCPs) and aesthetically acceptable to patients.

Methods. The study adopted the Medical Research Council framework for developing and evaluating complex interventions. Stage 1 involved a participatory co-design methodology. Multiple workshops were held with patient representatives and healthcare professionals (HCPs). Stage 2 involved phantom testing and testing on healthy volunteers (HVs) to confirm the S4A bra accuracy and potential to reduce the radiation dose to organs at risk. The final stage involved a clinical feasibility trial (n=50) to assess acceptability and functionality of the bra in the clinical setting.

To minimize bias we have adopted the following strategies across the different stages of the study:

- The workshops were audio recorded and transcribed verbatim. Qualitative analysis used a systematic and iterative process with two researchers coding the transcripts independently. An agreed coding scheme was developed through discussion, and member-checking was used to ensure trustworthiness of the data.
- During experimental testing, multiple set-ups were conducted to replicate a treatment course in bra and no bra conditions.
- In the feasibility trial fidelity checks were used to assess clinical use of the S4A bra in relation to its prescribed use.

Results Participants provided feedback on the design of the prototype bra allowing refinements to enhance patient comfort and usability for both patients and HCPs. Phantom testing demonstrated the bra was able to accurately position the breast phantom (3D displacements of 1.5mm and 1.3mm for S4A bra and no bra conditions). The HV study demonstrated the bra design lifts the breast away from the chest wall, which can aid treatment planning. Fifty patients have been recruited to a feasibility trial to assess acceptability.

Discussion. A participatory design methodology has facilitated the design of a bra that should meet end user needs. There have been a number of challenges throughout the innovation pathway that have been overcome through collaborative teamwork across the multiple agencies involved.

References
A breast imaging study to determine the efficacy of 3D kv-kv planar image matching for validating set-up of breast treatments.
Haughey A., McParland N., Lyons C., O’Connell B., Stewart D., Powell P., Best B.
North West Cancer Centre. Altnagelvin Area Hospital, L’Derry, Northern Ireland

Background The North West Cancer Centre (NWCC) has a standard policy of daily IGRT for all treatment. Breast planning at NWCC has evolved such that breast/nodal volumes are planned with a single mono-isocentric IMRT technique. This was previously considered as two separate plans, for which the imaging protocol mandated MV/kv imaging of the breast tangents plus an anterior kV image for the nodal volumes. Mono-isocentric IMRT is superior for both planning technique and treatment delivery but requires a kV image pair in order to cover the full length of the treatment field plus verification of treatment depth (not possible with the single anterior image) as it is sensitive to hot spots. A pilot study was established in order to ascertain the accuracy and efficiency of image-matching breast plans with kV imaging only. The images were evaluated to determine whether breast contour changes could be visualised on planar kV images.

Methods This study included patients planned either with breast-only tangents or the mono-isocentric breast/nodal technique. Cone Beam CT (CBCT) imaging was considered the ‘gold standard’ baseline for comparison. A daily imaging regime was established consisting of daily on-line image matching using an orthogonal kV image pair alongside weekly CBCT. Online matching was based on an automated bone match (including vertebrae, ribs and sternum) plus a best match to clips (if present). The CBCT was reviewed offline by the IGRT Specialist Radiographer and independently matched to the reference CT images. The difference in the matches between CBCT and the kV pair was noted. Changes in breast contour on CBCT were compared to contour changes noted on the kV/kV images. The acquisition and matching time of the kV pair was recorded directly from Aria™ (Varian Medical Systems).

Results Out of 20 mono-isocentric patients evaluated, 6 were unable to have a CBCT due to collision issues with the gantry. All patients recruited to the breast-only arm of the study (n = 14) had CBCTs without difficulty. For the 14 mono-isocentric patients who had CBCT, the mean difference between the kV/kV and CBCT match was 1.3 mm. In the breast-only group, the mean difference was 1.7mm. Three breast/nodal patients and five breast-only patients had notable contour changes on their CBCT which was observable on the kV images. Time required for kV/kV matching for the mono-isocentric group was a mean of 5.3 mins (mean 7 mins with previous technique). kV/kV matching time for the breast-only group was 3.8 mins on average (including an acquisition time of 29-seconds) and 2.4 mins (including 15-second acquisition time) for the kV/MV pair.

Discussion Evaluation of the kV/kV imaging against the reference CBCT shows that kV/kV image-matching provides accurate determination of patient set-up position. The analysis of the image-matching process shows that the mono-isocentric technique is more efficient using a kV/kV image pair. For breast-only patients, the kV/MV image pair was more efficient, in part due to prior radiographer experience and confidence assessing the MV image. Full CBCT is not always possible, due to patient set-up position and the location of the isocentre for the mono-isocentric technique.

Conclusion kV/kV imaging results in accurate verification of set-up for breast patients and can gain efficiencies in set-up verification. Changes in breast contour/seroma can be identified on a kV image.

Key References
3. Evaluation of implanted gold seeds for breast radiotherapy planning and on treatment verification: A feasibility study on behalf of the IMPORT Trialists. C.Coles et al. Radiother Oncol 2011;100;276-281
4. Clinical implementation of kilovoltage cone beam CT for the verification of sequential and integrated photon boost treatments of breast cancer patients. E.Donovan et al. British journal of radiology 2012;85:e1051-e1057
Challenges with Voluntary Deep Inspiration Breath hold (vDIBH): Capacity vs. Clinical need
Clough H Leeds Cancer Centre (LCC), Leeds Teaching Hospitals NHS Trust, UK.
Background
The NICE guidelines recommend use of a deep inspiration technique for all patients with left sided cancer to reduce the dose to the heart. The Leeds Cancer Centre treats around 1500 breast patients annually with approximately half being left sided. An equipment refresh program has placed additional pressures at a time when machine capacity was already tight. vDIBH increases appointment times at CT for coaching, and on the Linac during set up. Patient specific criteria were implemented, both before and after referral, to ensure resources were allocated appropriately and the technique could be accommodated without placing further strain on the department. The success rate for vDIBH is constantly monitored to ensure the critical factors of capacity and clinical need remain balanced.

Methods
A retrospective audit of all vDIBH referrals tracked scan outcomes over a one year period (2018). Data was separated into those patients who had a successful vDIBH scan and those that did not. For the latter, data was further investigated to look into reasons for failure.

Results

<table>
<thead>
<tr>
<th></th>
<th>No. of referrals</th>
<th>No. booked vDIBH scans</th>
<th>No. proceed with vDIBH</th>
<th>% for vDIBH</th>
</tr>
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<tr>
<td>Q1</td>
<td>75</td>
<td>67</td>
<td>32</td>
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<td>Q4</td>
<td>115</td>
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</tr>
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</table>

Discussion
The department used a MHD (Max heart distance) of ≥0.8 cm, measured on axial CT slices, to determine whether the patient would receive vDIBH. This is a linear measure on the free breathing scan which limits our vDIBH patient numbers by almost a quarter. The value was validated during initial implementation of the technique, the first patients being dual planned. It was shown that not only did MHD measurement strongly correlate with mean heart dose, but that a free breathing MHD of 0.8 cm correlated with a 50% reduction in mean heart dose from a vDIBH plan for the same patient. 50% is the average dose reduction from the implementation of vDIBH reported by multiple studies and was therefore deemed a clinically appropriate predictor of benefit from the technique.

Inconsistent breath holds and respiratory leaking were highlighted for improvement. New CT scanners are fitted with cameras to enable breath hold to be monitored, and a project with Sheffield Hallam University investigating visual information prior to a vDIBH scan, aims to increase patient opportunity for preparing and practicing their breathing, to improve chance of success.

Conclusion
Our criteria ensured we continued to deliver the technique to those who most benefit, whilst both referral and success rates increased over the period due to greater demand and familiarity with the technique. As our equipment refresh completes and capacity increases we hope to open out the benefits of vDIBH to more patients; as Darby reported, there is no safe lower threshold of irradiated heart volume.

Key references
1. NICE, Early and locally advanced breast cancer: diagnosis and management [online] 2018
Implementing Deep Inspiration Breath Hold and embracing new technologies.

1Hyland WB, 2Gilroy S, 3O’Connell B, 4Farrell S, 5Lynch A, 6Powell R, 7Lyons C, 8Reilly E, 9Reilly AJ.
1Radiotherapy Physics, 2 Therapeutic Radiography, 3Clinical Oncology, North West Cancer Centre (NWCC), Altnagelvin Hospital, Glenshane Road, Londonderry, N. Ireland, BT47 6SB, UK.

Background. Deep Inspiration Breath Hold (DIBH) is a commonly employed cardiac sparing technique in breast radiotherapy; offering reduced dose to the heart over and above what can typically be achieved in free-breathing1,3,4. In light of the clear correlation between radiation dose to the heart and cardiac morbidity, it is clinically advantageous to employ this technique where feasible, particularly for left-sided breast patients.2,5. In our centre, work has been carried out to clinically implement voluntary DIBH - applying a multidisciplinary approach to the implementation process, adopting new technologies where possible and appropriate and with the goal of achieving an efficient and stress-minimising patient process.

Methods. Voluntary DIBH was implemented in accordance with the departmental “evolution of clinical techniques” procedure, which is underpinned by multidisciplinary working. New technologies were adopted during clinical commissioning of the technique. At CT scanning, visual coaching was provided by Respiratory Gating for SCanners (RGSC) (Varian Medical Systems, Palo Alto, USA), then at treatment on TrueBEAM® 2.7 MR3 linacs (Varian Medical Systems, Palo Alto, USA) by integrated Visual Coaching Devices (VCDs). Automated couch-shifts from setup position to treatment isocentre were applied using the TrueBEAM® Delta Couch Shift functionality. Options for acquiring an orthogonal image pair to assess patient setup and allow online setup corrections to be applied were explored. In the interest of quality improvement and patient safety, multidisciplinary peer review – both local and external – was incorporated at every stage of the clinical implementation process.

Results. Visual coaching was successfully implemented and Delta Couch Shift functionality was successfully commissioned and is used clinically for all treatment sites. It was determined that the optimum verification imaging process involved utilising “triggered” imaging to acquire an orthogonal kV/MV setup pair during one breath-hold. A kV image is automatically acquired when the patient inhales and the breathing amplitude trace enters the defined “breathing window”. An MV image is automatically triggered when the patient exhales during the same breath-hold cycle as the trace leaves the breathing window. The independent multi-disciplinary review process proved successful in identifying outstanding work and moving the project forward to the next phase of implementation.

Discussion. Through multidisciplinary working, an efficient workflow for DIBH has been established that is integrated with and driven by the oncology management system. The workflow seeks to make full use of the latest technologies and available resources. Utilising common visual coaching hardware at both pre-treatment and during treatment ensures a consistent patient experience at each stage. Whilst the use of the Delta Couch function has not reduced patient setup times, it does provide a more automated approach to patient setup, minimising the risk of human error. Automatically triggered imaging streamlines the workflow at the treatment unit, increases the reproducibility of verification imaging, and minimises the number of breath-holds required per treatment, mitigating patient stress in return. By means of external and independent peer review, service quality and patient safety is evaluated and staff confidence is boosted.

Conclusion. Through multidisciplinary working and the adoption of new technologies, an efficient and patient-friendly workflow for DIBH has been established.

References
Abstract:

**Background:** Previously unable to treat the IMC in breast patients due to increase in dose to the lung and the contralateral breast. Consultant training and interest along with an increase in high risk breast patients lead us to look into a new method for treating these patients.

**Method:** Using RCR guidelines the department was able to come up with a planning technique using two partial arcs which treated the breast/IMC/SCF while keeping the dose the lung, heart and contralateral breast within the RCR guidelines. Dose prescription 40Gy 15 # with a minimum of 32Gy to the nodal regions. Ipsilateral lung V17 >35%, heart mean >6Gy, Contralateral breast >3.5Gy. Technique QA’d using Octavius and Portal Dosimetry looking at gamma of 3%/3mm and 2%/2mm.

**Results/discussion:** From September 2017 to December 2018 over 70 breast and chest wall patients have been treated with this technique. Over the course of the last 12 months, OAR doses have reduced significantly to enable us to work to and in 70% of cases meet new OAR doses set by the departmental consultants for right sided patients these are a heart mean of >2.5Gy, Ipsilateral lung V17 >20% and a cord dose of >10Gy. The department has also treated patients with SIB (48Gy 16#) using this technique, and also patients with difficult anatomy, for whom conventional radiotherapy using standard tangents (and in some cases matched on SCF/PostAX fields) would not be the most optimal treatment.

**Conclusion:** Now a widely used treatment technique in the department which all four breast consultants are happy to use for high risk patients.
Development of optimal treatment techniques for breast patients requiring IMC irradiation

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Background
Evidence suggest internal mammary chain (IMC) irradiation improves breast cancer survival [1,2] and overall survival [3]. For very high risk patients (eg: N3 disease) the benefit is convincing even using less modern radiotherapy (RT) techniques. However, patients with intermediate risk of recurrence are still likely to benefit providing normal organ irradiation is minimised to acceptable levels. Optimisation and standardisation of new RT photon techniques are essential prior to wider implementation of IMC irradiation particularly for those patients with disadvantaged anatomy.

Methods
The planning CTs of ten deep inspiration breath hold left sided breast patients were used for this retrospective study. The PTV for each patient combined the breast (cropped from body by 3mm), the IMC (levels 2-4) and the supraclavicular lymph nodes (SCF). Four plans were created for each patient using the following techniques (prescribed dose was 40Gy in 15 fractions):
1. Parallel-opposing wide tangent conformal fields with field-in-field segments (anterior beam used for SCF irradiation)
2. VMAT using four partial arcs
3. A hybrid technique of both VMAT and wide tangential fields
4. A hybrid of VMAT and conventional tangent fields, where the IMC was not covered with the conformal beams

Results
Discussion
The VMAT and both hybrid plans resulted in superior PTV coverage compared to the wide tangent plan. The VMAT plan and the hybrid plan with conventional tangent fields also reduced the V30Gy for both the heart and ipsilateral lung by an average of 1.32% and 7.7% respectively compared to the wide tangent plan. The three plans utilising VMAT increased the low dose volumes in the ipsilateral lung and increased the mean dose in the contralateral breast. However, the mean V5Gy for all VMAT and hybrid plans was 57.2% (49.1 – 64.3%), a reduction compared to other studies using VMAT by Osman et al. [4] and Tyran et al. [5] who recorded doses of 66.2% and 86.7% respectively (neither study included irradiation of the SCF).

Conclusion
Using VMAT alone and in combination with conformal fields created plans with superior breast, IMC and SCF dose coverage compared to using conformal fields alone. These techniques also reduced (or achieved similar) low dose volumes to the heart and ipsilateral lung when compared to other studies using VMAT.

References
A 2-year evolution of IMC treatment using VMAT, DIBH and online IGRT
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Background. Radical breast radiotherapy treatments that include the internal mammary chain (IMC) pose a considerable treatment planning challenge due to the proximity of organs at risk to the treatment site. While evidence has shown that extensive nodal radiotherapy is beneficial to high risk patients (1), planned and delivered dose distributions must also account for the existing evidence of cardiac and lung toxicity (2). Presented here are the radiotherapy planning and imaging techniques used in a single radiotherapy centre to treat 36 IMC patients over a 2 year period (2017-2019).

Methods. All patients were planned using Eclipse v11.0 (Varian Medical Systems) and treatments are delivered using Varian Clinac iX or TrueBeam. Both right and left-sided IMC treatments are considered for DIBH. Generally, VMAT bowtie arcs in combination with DIBH have been utilised for left-sided treatments and WT in DIBH have been used for right-sided treatments, although this decision is made on an individual patient basis. For online imaging, VMAT patients have daily CBCT images, while WT patients are verified daily using a kV/MV pair and a kV image of the clavicle region. For DIBH IMC patients, all imaging and treatment is gated using the Varian RPM system. All IMC patients also have an in-vivo dosimetry check in the first two treatment fractions, using either diodes or transit dosimetry.

Results.

<table>
<thead>
<tr>
<th></th>
<th>PTV BR/CW</th>
<th>PTV IMC</th>
<th>PTV N</th>
<th>Heart (Left-IMC)</th>
<th>Heart (Right-IMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V95(%)</td>
<td>V95sd</td>
<td>V90(%)</td>
<td>V90sd</td>
<td>Mean(Gy)</td>
</tr>
<tr>
<td>WT</td>
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<td>2.5</td>
<td>90.7</td>
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<tr>
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<td>7.8</td>
<td>95.7</td>
<td>6.4</td>
<td>6.1</td>
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<tr>
<td>RA Bowtie</td>
<td>93.0</td>
<td>5.4</td>
<td>95.4</td>
<td>5.7</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Table 1. PTV coverage statistics +/-1s.d for IMC patients at PCH

Discussion. The IMC planning process has evolved to find optimum patient-specific solutions to reduce predicted cardiac toxicity and also increase the delivered dose to tumour volumes. Overall, for left-sided patients, the VMAT bowtie technique in DIBH has achieved mandatory coverage of the breast/chestwall PTV and achieved improved coverage of the nodal PTVs while ensuring that the optimal constraints to the heart and lungs have been met. In comparison to VMAT with partial arcs, VMAT bowtie allows increased sparing of the OARs due to the reduced exit through the heart and lungs. For right-sided patients, the WT technique has achieved mandatory dose objectives for the breast and nodal PTVs while also achieving the optimal dose constraints for heart and lungs. For right-sided treatments, the WT in DIBH provides improved sparing of the heart and lungs in comparison to the VMAT bowtie technique.

Conclusion. The treatment technique for IMC patients must be considered on a case by case basis. However, our experience over the last two years has shown that the VMAT bow tie technique in DIBH and WT in DIBH with daily IGRT achieves our PTV objectives and OAR constraints.

Key references.