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17.15  Imaging – Michael Bradnam
17.25  Medical Equipment Management – Ted Mullen
17.35  Radiotherapy – Martin Glegg
17.45  I123-DaTSCAN: have we been slow on the uptake? – Colin Brown
17.55  Assessment of a Smartphone Application for the Objective Detection of Attentional Deficits in Delirium – Duncan Middleton

18.05  Buffet & Poster Session

Session 2

18.50  Education and Training – Doug Small
19.00  Impact of SPECT/MR Fusion on Paediatric Neuroblastoma Scores – Hugh Wallace
19.10  Influence of slice overlap on positron emission tomography image quality – Clare McKeown
19.20  Enabling analysis of high frequency clinical data at the bedside: update on the CHART-ADAPT project – Martin Shaw
19.30  Implementation of Diffusion Weighted MRI in Squamous Cell Cancer of the Oropharynx – Sarah Allwood Spiers
19.50  An Automated Monitoring System for Isolated Limb Perfusion – Chelsey Turner
Abstracts
**I123-DaTSCAN: have we been slow on the uptake?**

CM Brown\textsuperscript{1,2}, G Gillen\textsuperscript{1,2}

\textsuperscript{1}Dept of Clinical Physics & Bioengineering, Nuclear Medicine, Gartnavel General Hospital
\textsuperscript{2}University of Glasgow, College of Medical, Veterinary and Life Sciences (MVLS)

**Background**
Quantification of Single Photon Emission Computed Tomography (SPECT) images is an area of growing interest. By calibrating the gamma camera for absolute quantification images can be displayed using a normalised Standardised Uptake Value (SUV) scale.

**Materials and Methods**
An investigation was performed to evaluate the effect on Calibration Factor (CF) by varying Radius of Rotation (RoR), activity concentration and phantom for \textsuperscript{123}I SPECT. A further investigation assessed the SUVs of \textsuperscript{123}I-DaTSCAN studies to determine a standard display setting and evaluate the utility of SUV-SPECT for reporting.

**Key Results**
All patient examples demonstrated similar background SUV\textsubscript{mean}, ranging from 1-3 with a mean of 2. The SUV\textsubscript{max} of normal patients ranged from 13-20. Setting a standardised colour table, based on an SUV\textsubscript{max} of 15, enabled the observer to determine whether uptake in the caudate and/or putamen was reduced.

**Conclusion**
SUV-SPECT can be used to aid the reporting of \textsuperscript{123}I-DaTSCAN patient studies. In particular, fixed colour tables, based on normal datasets, standardise background levels and facilitate authentic assessment of uptake in the striatum.
Assessment of a Smartphone Application for the Objective Detection of Attentional Deficits in Delirium


1 Institute of Cardiovascular and Medical Sciences, University of Glasgow, Glasgow
2 Edinburgh Delirium Research Group, Geriatric Medicine, University of Edinburgh, Edinburgh
3 Edinburgh Clinical Trials Unit, Centre of Population Health Science, University of Edinburgh, Edinburgh
4 Edinburgh Health Services Research Unit, Centre for Population Health Sciences, University of Edinburgh, Edinburgh
5 Institute of Mental Health & Wellbeing, University of Glasgow, Glasgow
6 Anaesthesia, Critical Care & Pain Medicine, University of Edinburgh, Edinburgh
7 Department of Critical Care, Intensive Care Unit, Edinburgh
8 Anaesthesia, Critical Care & Pain Medicine, Glasgow Royal Infirmary, Glasgow
9 Medical Devices Unit, NHS Greater Glasgow and Clyde, Glasgow
10 Cambridge Cognition Ltd, Cambridge

Background

The ability to obtain accurate assessment of patients for delirium and other cognitive disorders remains a significant challenge in the healthcare profession. Although several validated tools for the assessment of delirium are available they do not adequately discriminate from dementia and there is a lack of detailed research on their objectivity. The use of software applications on smartphones can help in providing objective, accurate and reproducible results for such assessments. Here we examined the diagnostic performance of the DelApp Android app in hospitalised patients in both ICU and non-ICU wards.

Materials and Methods

DelApp has been developed to provide a simple cognitive test for use in the assessment of delirium scoring patients on a scale of 0-10. The first part of the assessment includes an arousal and visual attention pre-test, to confirm the patient has no problems with either of these. The main part of the assessment is a sustained attention test which consists of a series of stimuli presented on screen which the patient is asked to count. There are both ICU and non-ICU version of the assessment, whereby the ICU version is adapted for use in non-verbal (i.e. ventilated) patients.

Case-controlled studies administered by independent blinded researchers of patients in both ICU and non-ICU wards has been carried out where assessment for delirium using the smartphone app was compared to a reference standard delirium assessment based on DSM-5 criteria. In the ICU study 115 patients (delirium N=53, no delirium N=62) aged 18-95 years (median 62 years) were recruited. In the non-ICU study 188 patients (delirium N=61, dementia without delirium N=62, no dementia or delirium N=65) aged over 65 (median 85 years) were recruited.

Key Results

In both the ICU and non-ICU wards patients had lower scores on the DelApp assessment than those with no delirium. In the ICU ward for patients with delirium the median score (MS) = 2 with an inter-quartile range (IQR) = 2-4 while for those with no delirium the MS = 10 with an IQR of 9-10. In the non-ICU ward for patients with delirium the MS = 4 with an IQR = 3.5-5, for patients with dementia the MS = 9 with an IQR of 5.5-10 while for those with no delirium or dementia the MS = 10 with an IQR of 10-10. In both wards the DelApp assessment was found to have good accuracy in determining instances of delirium.

Conclusion

A study carried out to test a smartphone app which has been developed for the diagnosis and assessment of delirium, carried out in both ICU and non-ICU wards, has found the app to be an objective, sensitive and specific tool for detecting delirium. A further validation study in unselected patients is underway to determine its formal diagnostic utility.
Impact of SPECT/MR Fusion on Paediatric Neuroblastoma Scores

HJ Wallace\textsuperscript{1,2,3}, MS Bradnam\textsuperscript{1,3}, AA Bolster\textsuperscript{2,3}, J Foster\textsuperscript{1,3}, H Kaur\textsuperscript{1}, A Watt\textsuperscript{1}, GJ Irwin\textsuperscript{1,3}, D Murphy\textsuperscript{1}, M Ronghe\textsuperscript{1}, J Sastry\textsuperscript{1,3}

\textsuperscript{1}Royal Hospital for Children, Glasgow
\textsuperscript{2}Department of Nuclear Medicine, Glasgow Royal Infirmary
\textsuperscript{3}University of Glasgow

Background
Neuroblastoma is an embryonal cancer most commonly diagnosed in the first year of age. While a minority of cases have the potential to spontaneous regress to a benign form, the majority of cases are classified as high risk and have a very poor prognosis. Overall this disease is responsible for more childhood mortality than any other solid cancer outside of the brain. Recent published work [1] has shown that semi-quantitative scoring methods applied to MIBG scintigraphy correlates strongly with patient survival. However, these methods are based solely on planar imaging and may be improved by the inclusion of tomographic imaging such as SPECT/CT or SPECT localised using MRI.

Materials and Methods
Clinical reports and image data for I123-MIBG scintigraphy appointments over a 2 year period were reviewed retrospectively. 15 patients were identified with readily available SPECT/MR imaging. In each case the earliest available time-point was used for MIBG scoring. Wholebody and planar images were scored by a single observer using the SIOPEN and Modified Curie scoring systems. Each image set was then re-scored with the addition of SPECT/MR. The difference in two scores was calculated for each case.

Key Results
Differences in total score as a result of the addition of SPECT/MR information were observed in 33\% (5/15) and 73\% (11/15) of cases for SIOPEN and Curie scores respectively. The range of differences observed were [0, 6] for the SIOPEN score and [-2, 5] for the Curie score. Statistical analysis demonstrated a small but significant difference in SIOPEN score of approximately 1.1 score units on average. Analysis of the Curie score revealed no statistically significant difference with the addition of SPECT/MR.

Published work suggests that SIOPEN and Curie thresholds of 4 and 2 score units provide optimum stratification of the patient population into low and high risk groups at initial diagnosis. With the addition of SPECT/MR, both the SIOPEN and Curie scores for one subject increased from below these respective thresholds to higher score values. This suggests that clinically significant information may be introduced by the inclusion of SPECT/MR in the scoring process.

Conclusion
SPECT/MR fusion provides a statistically significant difference to the SIOPEN score and may introduce clinically significant information to the MIBG scoring process. Follow up work is required to assess the reproducibility of these initial results.

References
Influence of Slice Overlap on Positron Emission Tomography Image Quality
Clare McKeown, Gerry Gillen, Mary Frances Dempsey, Caroline Findlay
The PET Centre, Gartnavel General Hospital

Background
PET scans are acquired using overlapping frames to correct for reduced sensitivity at frame edges. Some vendors have fixed overlaps while others allow operators to select overlap size. The optimum overlap for the GE Discovery 690 has not been established. This study aims to assess how image quality is affected by slice overlap. In particular, it compares a 23% overlap with the maximum 49% overlap, with reference to recent EANM guidelines.

Materials and Methods
A uniform flood phantom was used to assess noise (Coefficient of Variation, COV) and voxel accuracy (activity concentrations, Bq/ml). A NEMA body phantom with hot/cold spheres in a background activity was used to assess mean Contrast Recovery Coefficients (CRCs) and Signal to Noise Ratios (SNR). Hot sphere phantoms were filled using both 4:1 and 2:1 sphere-to-background ratios.

Key Results
COVs for 49% and 23% overlaps were 10% and 13% respectively. This increased noise was difficult to visualise on the 23% overlap images. Mean voxel activity concentrations were not affected by overlap size.

No clinically significant differences in hot or cold CRCs were observed as the overlap was altered, regardless of sphere-to-background ratio or phantom activity.

Visualisation and SNR of low contrast small spheres, however, may be affected by overlap size in low count studies. The 2:1 ratio 13mm diameter sphere was visible on 5/6 acquisitions with 49% overlap (average SNR = 6.4) but was only visible on 3/6 acquisitions with 23% overlap (average SNR = 3.9). However, detectability of the 13mm sphere was only affected when the phantom background activities were below those typically observed in patient livers.

EANM guidelines for weight-based FDG administrations suggest that minimum injected activities should be doubled when <30% overlap is used. This experiment demonstrated little difference in image quality either side of this 30% overlap threshold.

Conclusion
There was minimal detectable influence on image quality in terms of noise, mean activity concentrations or mean CRCs when comparing 23% overlap with 49% overlap. Detectability of small, low contrast lesions may be affected in low count studies – however, this is a worst-case scenario. The marginal benefits of increasing overlap from 23% to 49% are likely to be offset by the disadvantages of increased patient scan times. A 23% overlap is therefore appropriate for clinical use for the GE Discovery 690. The 30% overlap threshold suggested by EANM guidelines when calculating weight-based FDG administrations may require revision.
Enabling analysis of high frequency clinical data at the bedside: update on the CHART-ADAPT project.

Laura Moss¹, Martin Shaw¹, Ian Piper¹, Christopher Hawthorne², John Kinsella², Aridhia, Philips Healthcare

¹Dept of Clinical Physics & Bioengineering, Institute of Neurological Sciences, Queen Elizabeth University Hospital,
²Dept. of Anaesthesia, Pain & Critical Care, University of Glasgow, Glasgow, UK.

Background
To enhance patient treatment at the bedside and drive advances in clinical knowledge and how clinical research is conducted, high frequency clinical data (e.g. waveform signals) could be linked to low frequency data (e.g. electronic clinical records). However, due to the size and complexity of this data, these analyses are difficult to perform and complete in clinically meaningful timescales. We provide an update on a collaboration (CHART-ADAPT) between NHS Greater Glasgow & Clyde, Aridhia, Philips Healthcare, and University of Glasgow examining the use of high performance computing (HPC) as a solution to this problem.

Materials and Methods
CHART-ADAPT (http://www.chartadapt.org) extracts high and low frequency data from in-hospital patient monitoring systems and enables the use of physiological models and algorithms. The data is automatically transformed into HL7, anonymised and transferred to Aridhia's AnalytiXagility platform; this provides storage of high-frequency data, delivers an analysis engine, supports the development and deployment of clinical analysis algorithms, and an app which will enable clinicians to control analyses. Finally, results from the algorithms will be presented at the patient's bedside on the same system (Philips ICCA) used to collect the data. The project will be demonstrated at the Neurointensive care unit, Neurosciences Institute, Glasgow, and will be used for the application and research into hypotension and autoregulation models.

Key Results
The initial stages of the CHART-ADAPT software and infrastructure have been completed and data analysis is currently being performed on live data streams in the Neurointensive Care Unit with results immediately available on patient monitoring equipment. Extended testing is underway and clinical research projects have commenced.

Conclusion
The CHART-ADAPT project will continue to build on this initial research. By enabling clinically important physiological models and algorithms to be implemented more quickly into clinical practice, CHART-ADAPT has the potential to revolutionise the treatment of patients.

Acknowledgements
This project was co-funded by Innovate UK.
Implementation of Diffusion Weighted MRI in Squamous Cell Cancer of the Oropharynx


Department of Clinical Physics and Bioengineering, NHS Greater Glasgow and Clyde.
Department of Clinical Oncology, Beatson West of Scotland Cancer Centre, NHS Greater Glasgow and Clyde.
Department of Radiology, Queen Elizabeth University Hospital, NHS Greater Glasgow and Clyde.

Background
Diffusion weighted MRI (DWI) is a useful technique in cancer diagnosis, with tumours showing restricted diffusion. The apparent diffusion coefficient (ADC) calculated from DWI images gives a quantitative measure of the rate of diffusion, and ADC values may correlate with tumour response to treatment [1-4]. MeRInO is a local study assessing DWI as a predictive biomarker during radiotherapy for squamous cell cancer of the oropharynx. Patients will have DWI scans before radiotherapy and in week 3 of radiotherapy treatment, to assess whether the change in ADC of the tumour region during radiotherapy correlates with treatment response.

Aim: To establish an imaging protocol and ensure ADC values obtained are reliable in preparation for MeRInO.

Materials and Methods
The MRI protocol was developed using a phantom to assess the accuracy of the ADC measurement [5,6]. The phantom contains several vials of PVP solution and 1 vial of distilled water and was scanned at 0°C. Images of healthy volunteers were used to assess distortion and image quality and to investigate the choice of scan parameters. Images were acquired on a GE Signa 1.5T HDxt scanner.

Key Results
The ADC values of the PVP solutions covered the clinical range of interest for tumours and healthy tissue. Images of 3 patients have been obtained, each showing restricted diffusion in the tumour.

Conclusion
The PVP phantom is useful in QA of DWI. Images of volunteers were necessary to assess distortion and image quality. The first patient images show good depiction of the tumour in the ADC map.

References
Validation of a Visual Impairment Simulator, SightSim™

Julia Scott¹, Ruth Hamilton², Alexander Weir³, Michael Bradnam²
¹Dept of Clinical Physics & Bioengineering, Queen Elizabeth University Hospital
²Dept of Clinical Physics & Bioengineering, Royal Hospital for Children
³Dept of Clinical Physics & Bioengineering, Medical Devices Unit, West Glasgow Ambulatory Care Hospital

**Background**

SightSim™ is a visual impairment simulator designed to provide the carers of visually impaired children with a pictorial representation of their child's sight. The application aims to reduce the confusion which can be created when clinicians describe a child's visual ability using measurements of visual acuity and contrast sensitivity. During the project, a validation of the SightSim™ application was conducted to quantify the accuracy of visual acuity and contrast sensitivity simulations it produces.

**Materials and Methods**

The SightSim™ software underwent verification using a gold standard developed using Matlab (Mathworks, U.K), which identified four main errors in the code. These errors were removed during the development of a new version of the software for the purpose of validation. A review of the protocol and results of a preliminary validation which took place in 2012 was carried out. Further validation experiments were designed and conducted using a cohort of 28 normal, healthy adults. The results quantified the accuracy of the visual acuity emulation, and assessed the contrast sensitivity emulation for the first time.

**Key Results**

Each subject was tested using two visual acuity tests and one contrast sensitivity test. By measuring subject's acuity at different simulated acuities, it was found that, on average, the measured visual acuity was between 0.13 and 0.20 logMAR better than the acuity simulated by SightSim™. This is an improvement in accuracy compared to the preliminary validation results, though there was no marked difference in their variability. The contrast sensitivity test assessed the accuracy of the simulations by measuring the contrast sensitivity threshold of the subjects at different levels of simulated contrast. Subjects were able to identify lower contrast triplets as the simulated contrast was increased. The recognisability of the letter set used in the test charts was also analysed.

**Conclusion**

The changes made to the SightSim™ code during this project have increased the accuracy of the visual acuity emulation, though an on-set (error) still persists. Conducting verification and further validation experiments has increased understanding of the SightSim™ software algorithms which will allow the project to progress. The most likely development will be towards a mobile version of the application.
An Automated Monitoring System for Isolated Limb Perfusion

Chelsey Turner¹, Jamie Wright¹, Alison Bolster¹
¹Dept of Nuclear Medicine, Glasgow Royal Infirmary

Background
As part of the new Scottish Medical Physics training scheme an innovation project has to be completed during the specialism period, the decision was made to design and build a proof of concept device for the automatic monitoring of leakage during isolated limb perfusion procedures.

Once isolation of the limb is complete it is necessary to monitor any leakage from the limb into the systemic blood. To do this the red blood cells in the systemic and bypass circulations are labelled with Tc99m (in vivo) using Pyrophosphate (PYP). 16MBq of Tc99m is administered to the patient's systemic blood, a gamma probe is positioned above the left ventricle and a baseline measurement is made. A further 160MBq of Tc99m is administered to bypass blood circulating the isolated limb. Left ventricle counts are measured every 5 minutes and the percentage leakage is calculated using an Excel spreadsheet.

Due to the high levels of cytotoxic drugs in the limb and the potential for adverse side effects to the patient it is extremely important that any leakage from the limb is measured. The current procedure requires two members of nuclear medicine staff to be present throughout the entire surgical procedure and for contamination monitoring after the procedure is finished.

Materials and Methods
As with the current practice, the gamma probe will be positioned over the left ventricle and the number of counts measured every 5 minutes. However, instead of manually transcribing the readings to the Excel spreadsheet a raspberry-pi single board microcomputer and attached touch screen interface will be connected to the serial port on the gamma probe. Software written in the Python programming language will be used to decode the gamma probe output and display the results along with a real time plot of leakage on the touch screen interface.

Future Considerations
The project is still in a relatively early stage, it has been possible to read in and decode the output from the gamma probe as well as creating some basic electronics using a breadboard. The touch screen user interface is the next task that will be undertaken.

It is hoped that expertise from other areas of DCPB will be available to help when it comes to creating a method for instigating the gamma probe and in the design of an infection control friendly case.
Gaze Tracking for Eye Tests

Paul McCool
Medical Devices Unit, West Glasgow Ambulatory Care Hospital

Objective
As part of a wider initiative examining the optimisation of standard eye assessments, this study is investigating how gaze tracking can be integrated into visual field, acuity and electrophysiological tests in order to:

i. Improve the accuracy of the tests.
ii. Reduce the training and experience requirements of the clinicians.
iii. Make eye tests quicker and more comfortable.
iv. Allow novel approaches to assessment of the visual system to be developed.

Background
Gaze tracking allows a user to control a computer using their eyes. The computer responds in some useful way to where the user is looking on the screen. For example, people who are paralysed might still have eye control and so might be able to control speech synthesis or a wheelchair.

There are several kinds of measurements that can be taken [1]:

- **Presence** of user: Is someone sitting in front of the machine?
- **Distance** from screen: Determine how far the eyes are from the screen.
- **Fixation**: Is the user staring at the fixation target that is displayed on the screen?
- **Gaze location**: Where is the user looking on the screen?
- **Saccade**: The eye ‘jumps’ towards new targets. This jump is called a saccade and it has direction and magnitude.

Gaze tracking works by shining near infrared (NIR) light on the eye, which is invisible, and measuring the reflections on the eyeball relative to the centre of the pupil using an IR camera. This is calibrated by first measuring reflection positions for known reference points on a computer screen. Current visual perimeter and visual field tests require constant fixation by the patient [2] (which is difficult) and careful monitoring by the clinician, who must be highly trained and experienced. Visual acuity and electrophysiological eye tests might also benefit from gaze tracking.

Materials and Methods
A Tobii EyeX was used. Each of the identified use cases were simulated using Matlab and Psychtoolbox software, with gaze tracking integrated into the test. For example, perimetry was tested by measuring when the patient’s gaze saccaded from a fixation point to an incoming target.

Key Results
Experience with the Tobii EyeX has indicated that gaze tracking has the potential to improve the speed, comfort and accuracy of perimetry and visual field tests while reducing the requirement for intense clinician training, experience and concentration. Automated fixation monitoring and saccade measurement could be used in electrophysiological and acuity tests.

Conclusion
A gaze tracking system is now being built in order to understand how best use can be made of gaze tracking for eye tests.

Several of the new virtual reality headsets have built-in gaze tracking [3]. Future work may involve assessing their potential for perimetry and visual acuity tests.

References
18F-Fluciclovine: A New Amino Acid PET Tracer for Cancer Imaging

Sue Champion, Sally Pimlott, Jonathan Owens

PET Radiopharmaceutical Production Unit, West of Scotland PET Centre, Gartnavel General Hospital

Background

11C-methionine is the most well characterised amino acid-based PET agent however, this carbon-11 labelled tracer has a very short half-life (20min), and its preparation requires a cyclotron on site. 18F-Fluciclovine (also known as 18F-FACBC) (Fig 1.) is a novel 18F-labelled synthetic amino acid for PET imaging. Preliminary studies in prostate cancer [1] and glioma [2] suggest 18F-Fluciclovine has potential benefits over 11C-methionine. In addition, the longer half-life of 18F (110 mins) makes 18F-Fluciclovine more widely available.

At the start of 2016 the only 18F-Fluciclovine production site in the UK was the GE Healthcare site (Amersham). Although they have supplied as far north as Leeds, supply to north England and Scotland is not considered viable. The aim of this study was to set-up the production of 18F-Fluciclovine at Glasgow’s PET Radiopharmaceutical Production Unit (PET RPU).

Materials and Methods

A process validation study was performed involving three consecutive 18F-Fluciclovine batch productions with quality control testing at 0hrs and 10hrs. 18F-Fluciclovine, was produced using a pre-loaded cassette on the GE Fastlab Synthesiser.

![Fig 1. Chemical Structure of 18F-Fluciclovine](image1)

![Fig 2. A GE Fastlab Synthesiser](image2)

Quality control testing included determination of chemical and radiochemical purity and identity, radionuclide identity and purity, residual solvent & endotoxin content, and sterility of the final product.

Key Results

Three batches of 18F-Fluciclovine were produced with end of synthesis yield 49.99 ± 2.11% with a final radioactivity concentration of 200MBq/ml at reference time. The results of the quality control tests at both 0 and 10hrs met the product specification, showing the product was fit for purpose.

Conclusion

The set-up of the production of 18F-Fluciclovine for use in clinical trials has been achieved. 18F-Fluciclovine will be produced for a UK multi-centre Phase III clinical trial investigating the utility of the tracer in recurrent prostate cancer. In addition, we are planning a Scottish-wide multi-centre study investigating the potential of 18F-Fluciclovine for imaging pseudoprogression in glioblastoma patients.

Acknowledgements

We would like to thank the Beatson Endowment Fund for providing funding for the GE Fastlab Synthesiser. The set-up of the production of 18F-Fluciclovine was funded by an Innovate UK grant in collaboration with Blue Earth Diagnostics. This work was completed with help from all the technical staff at the PET RPU.

References


Incidental CT findings from Myocardial Perfusion SPECT/CT

Alastair Gemmell¹, John Morrison²
¹Department of Nuclear Medicine, Queen Elizabeth University Hospital
²Department of Radiology, Queen Elizabeth University Hospital

Background
With the increasing use of CT in Nuclear Medicine for attenuation correction of Myocardial Perfusion imaging (MPI), the recently updated EANM MPI guidelines recommend that the CT be screened for incidental and extra-cardiac findings (1). While some studies have concluded that routine viewing of the CT is not necessary due to the low rate of significant findings (2), other studies have disagreed, citing ethical & legal grounds (3), and the potential for detecting unknown pathologies (4). An audit of MPI CT data was carried out to determine the practicality of routine reporting of the CT component, and the detection rate of incidental findings.

Materials and Methods
Patients undergoing MPI on a Siemens Symbia Intevo Excel or Intevo 16 receive a CT for attenuation correction purposes only (130 kV, effective mAs of 17 with automatic tube current modulation (CareDose4D)).

48 consecutive MPI patients over a 3 month period were audited, with reconstructed CT images (3 mm slices, B40 smooth kernel) viewed by an experienced consultant radiologist across a range of CT window widths & levels.

Key Results
Of the 48 scans reviewed, 37 (77.1%) showed no abnormality. A further 9 scans (18.8%) showed a clinically insignificant incidental finding, while 2 scans (4.2%) showed significant findings requiring follow-up. One was a new finding of recurrent breast cancer with new lung metastases, and the other was determined to be an intraparenchymal lymph node of no significance on follow-up diagnostic CT with contrast.

The radiologist found that while images were often degraded by breathing artefact and of insufficient quality to interpret small nodules, image quality was sufficient to identify abnormalities of potential clinical significance.

Conclusion
While the review of CT scans acquired for attenuation correction showed only a small number of patients with findings requiring follow-up, the potential for discovering significant pathology that would have serious impact to patient’s treatment lends weight to routine review of these images, which has now been adopted by this centre.

References
MFER Representation of Neurointensive Care Waveform Data:

A Pilot Study

Ian Piper1, Martin Shaw1, Christopher Hawthorne2, John Kinsella2, Laura Moss1

1Dept of Clinical Physics & Bioengineering, Institute of Neurological Sciences, Queen Elizabeth University Hospital,
2Dept. of Anaesthesia, Pain & Critical Care, University of Glasgow, Glasgow, UK.

Background
Technology in Neurointensive Care Units is able to collect and store vast amounts of complex patient data. The CHART-ADAPT project aims to develop technology which will allow for the collection, analysis, and use of this big data at the patient’s bedside in Neurointensive Care Units. A requirement of this project is to automatically extract and transfer high frequency waveform data (e.g. ICP) from monitoring equipment to high performance computing infrastructure for analysis. Currently, no agreed data standard exists in Neurointensive care for the description of this type of data. In this pilot study we investigated the use of MFER (www.mfer.org) as a possible data standard for Neurointensive care waveform data.

Materials and Methods
Several waveform formats were explored (e.g. XML, DICOM Waveform) and evaluated for suitability given existing computing infrastructure constraints e.g. NHS network capacity and the processing capabilities of existing integration software. Key requirements of the format included a compact data size and the use of a recognised standard. MFER waveform format (ISO/TS 11073-92001) met both of these requirements. To evaluate the practicality of the MFER waveform format, 7 waveform signals (ICP, ECG, ART, CVP, EtCO2, Pleth, Resp) collected over a period of 8 hours from a patient at the Institute of Neurological Sciences in Glasgow, were converted into MFER.

Key Results
MFER has two main components: sampling information and frame information. Sampling information describes how frequently the data is sampled and what the resolution of the data is. Frame information describes the data itself; it consists of 3 elements: data block (the actual data), channel (each type of waveform data occupies a channel) and sequence (the repetition of the data). Figure 1 shows a sample MFER file. All 7 waveform signals were automatically converted into MFER successfully. One MFER file was created for each minute of data (total of 479 files, 181 KB each).

Conclusion
MFER has potential as a lightweight standard for representing high frequency Neurointensive care waveform data. Further work will include a comparison with other waveform data formats and a live trial of using MFER to stream patient data over a longer period of time.

Acknowledgements
CHART-ADAPT (http://www.chartadapt.org) is an Innovate UK co-funded project and the project partners are: Aridhia, Philips Healthcare, University of Glasgow and NHS Greater Glasgow and Clyde.
Figure 1- Example MFER data. The MFER viewer shows one blob of MFER data. Viewable in the top section is information about each of the channels (i.e. the sampling information). At the bottom of the screen is a visualization of one of the channels.
Design and Validation of a Volume Reconstruction Algorithm from 2D Tomographic Slices

G. Reines March\textsuperscript{1,2}, X. Ju\textsuperscript{1}, S. Marshall\textsuperscript{2}

\textsuperscript{1}Medical Devices Unit, West Glasgow ACH, Dalnair St. G3 8SJ Glasgow
\textsuperscript{2}Hyperspectral Imaging Centre, Dept. of Electronic and Electrical Engineering, Univ. of Strathclyde, 204 George St. G1 1XW Glasgow

Background

Image registration techniques have proven useful in biomedical sciences for merging different sources of visual information in a common spatial reference frame (e.g. PET/CT scans used in oncology). The ultimate goal of our project is to validate the accuracy of several PET radiotracers used in cancer diagnosis and monitoring, which can only be achieved by mapping these 3D scans to areas of known cancerous activity, determined by the gold standard of histopathology. Prior to performing volumetric registration, histopathology slices and their corresponding block-face photographs must be stacked together in order to reconstruct their 3D structural information. For assessing the volume reconstruction algorithm, we designed a sliceable phantom and fixed it in agar jelly, in order to compare and validate the results with the ground truth measurements.

Materials and Methods

The phantom was built by mixing 7\% by weight of poly(vinyl alcohol) powder (PVA, 99+\% hydrolysed, Sigma-Aldrich UK Ltd, Dorset, UK) with water. Red food colouring powder was added for dyeing the solution. After allowing the mixture to cool to room temperature, it was poured into a mould. Then the solution underwent two freeze-thaw cycles in order to create a solid cryogel.

Afterwards, the phantom was fixed in a 4\% by weight solution of agar powder (Agar Agar E406, 100\% pure, Special Ingredients Ltd, Chesterfield, UK). Once set, the block was sliced at 5mm intervals with a custom-built soft tissue slicing rig and photographs of each section were taken with a digital camera (Canon EOS M3, Canon Inc., Tokyo, Japan). Image processing and analysis are performed using Matlab R2016a (The Mathworks, Natick, Massachusetts, USA).

Key Results

Ground truth phantom volume was calculated by immersion in water. In order to establish a correspondence between pixels and real world units, ImageJ was used to measure the pixel size of a fiducial marker of known size placed inside the camera's field of view. Preliminary results showed a substantial disagreement between the reconstructed structure and the ground truth measurements (18.3\% difference). After a visual inspection of the reconstructed volume, it was observed that the interpolation in z axis was done using a nearest-neighbour approach, resulting in a smaller overall volume. The segmentation of the phantom area also posed a problem, as the phantom-agar boundary was not well defined, therefore giving place to non-regular sections. In the preliminary experiments, segmentation was performed by manual colour thresholding on the L*a*b* colour space. It is expected however that real lung specimens will be easier to distinguish from the surrounding due to their higher contrast, and semiautomatic segmentation algorithms will be used.

Conclusion

Initial results showed a large difference between reconstructed and measured volumes. However, the principal shortcomings of the current implementation have been detected and are currently addressed in a second version of the algorithm.
Qualitative assessment of image quality with Siemens xSPECT reconstruction

Alastair Gemmell¹, Ana Catarina Matos², Louise Wason³, Alice Nicol¹
¹Department of Nuclear Medicine, Queen Elizabeth University Hospital
²Department of Nuclear Medicine, Gartnavel General Hospital
³Department of Nuclear Medicine, University Hospital Ayr

Background
Siemens xSPECT (Erlangen, Germany) is a new acquisition & reconstruction package that aims to improve image quality through improved system modelling, use of CT data to create zone maps, and an ordered-subset conjugate gradient minimisation reconstruction algorithm, with Mighell's $\chi^2$ merit function (1).

Materials and Methods
This study compared image quality between xSPECT and the current local standard acquisitions using Flash3D reconstruction. Images were compared both for phantom studies and for a number of patient studies.

Images were acquired of a Jaszczak phantom (Data Spectrum, Durham USA) filled with Tc-99m Pertechnetate & containing cold spheres & cold rods, and repeated with hot spheres & hot rods. Patients undergoing bone SPECT/CT had their images reconstructed with both xSPECT Bone and Flash3D (n=11).

Key Results
After reconstruction with both xSPECT and Flash3D, review of the Jaszczak phantom images by an experienced observer suggested that xSPECT produced qualitatively better resolution & contrast, though with a different noise appearance.

For the patient images, in two cases the xSPECT Bone reconstructions were judged by an experienced observer to provide additional information not available with the Flash3D reconstruction, due to improved localisation.

Conclusion
Further work is required locally to optimise our reconstruction parameters for the xSPECT package. However, initial phantom studies and patient images suggest that xSPECT has the potential to improve image quality.

References
[1] Siemens White Paper “Introduction to xSPECT Technology”
In vivo characterisation of a novel tracer for PET imaging of PARP-1

Filip Zmuda¹, Gaurav Malviya², Adele Blair³, Andrew Sutherland³, Anthony Chalmers⁴, and Sally Pimlott¹

¹PET-RPU, West of Scotland PET centre, Gartnavel General Hospital
²Nuclear Imaging, Cancer Research UK Beatson Institute
³School of Chemistry, University of Glasgow
⁴Wolfson Wohl Cancer Research Centre, Institute of Cancer Sciences, University of Glasgow

Background
Poly(ADP-ribose) polymerase-1, PARP-1, is involved in repair of DNA breaks and is overexpressed in a wide variety of tumours. These tumours can be sensitised to conventional chemotherapy by introducing a PARP-1 inhibitor (PARPi) such as olaparib. Imaging of PARP-1 expression in vivo is a potentially powerful tool for developing PARPi for drug discovery and also for cancer diagnosis, staging and monitoring. To date, there are no clinical PARP-1 molecular imaging tracers in existence. We have previously reported the development of a lead positron emission tomography (PET) tracer candidate, FZ236, based on olaparib [1]. Here we report preliminary in vivo characterisation of this PET tracer.

Materials and Methods
Radiolabelling of FZ236 with ¹⁸F was performed via a nucleophilic substitution reaction of the corresponding chlorinated precursor. The biodistribution of [¹⁸F]-FZ236 was investigated in subcutaneous U87MG tumour bearing nude mice at 30 (n=4), 60 (n=4) and 120 minutes (n=4) post-injection by gamma-counting of harvested organs. PARP-1 binding specificity was assessed by pretreating tumour bearing mice with either vehicle or unlabeled olaparib 20 minutes before administration of [¹⁸F]-FZ236.

Key Results
¹⁸F-FZ236 was obtained with a 49.1 ± 9.7% (n=8) ¹⁸F incorporation yield and an end of synthesis yield of 9.3 ± 2.0% (n=7). Between 30 and 120 minutes post injection of [¹⁸F]-FZ236 the tumour to muscle ratio increased from 1.92 ± 0.50 (n = 4) to 3.61 ± 0.46 (n = 4) suggesting retention of the tracer in tumour tissue. The tumour to bone ratio at 120 minutes was 0.030 ± 0.003 (n=4). Pre-treatment with olaparib resulted in a significant reduction in the tumour to muscle ratio when compared to the vehicle control cohort, confirming specificity of [¹⁸F]-FZ236 for PARP-1 in vivo.

Conclusion
A lead PET tracer candidate for non-invasive molecular imaging of PARP-1 has been developed and synthesised in a respectable radiochemical yield. Preliminary in vivo data shows [¹⁸F]-FZ236 is taken up and retained in tumour and this uptake is due to specific binding to PARP-1. High uptake was also seen in the bone, possibly due to de-fluorination in vivo.

Acknowledgements
The authors would like to thank the following organisations for financial support: the Engineering and Physical Sciences Research Council, the University of Glasgow, and Cancer Research UK.

References
Pilot Evaluation of a De-Identification Tool for Neurointensive Care Unit Data

Laura Moss¹, Martin Shaw¹, Ian Piper¹, Christopher Hawthorne, John Kinsella, Philips Healthcare, Aridhia

¹Dept of Clinical Physics & Bioengineering, Institute of Neurological Sciences, Queen Elizabeth University Hospital,
²Dept. of Anaesthesia, Pain & Critical Care, University of Glasgow, Glasgow, UK.
³Wellcome Surgical Institute, University of Glasgow – edit as appropriate,

Background
The continuing digitalization of Neurointensive Care has led to the development of technology that is able to collect and store large amounts of complex patient data. Additionally, as we move towards precision medicine, the possible future use of genomic and proteomic data at the patient’s bedside will increase the requirements for technology and tools which can support the analysis of this ‘big data’. Commonly, big data solutions require the transfer of data to cloud-based services which provide the infrastructure to enable the efficient processing of large volumes of data. However, safeguards have to be put in place to maintain the confidentiality of patient data. The CHART-ADAPT project (http://www.chartadapt.org) aims to develop technology which will allow for the collection, analysis, and use of this big data at the patient’s bedside. In this abstract we describe the evaluation of the Automated Neurointensive Care Anonymisation (ANCA) software, developed as part of the CHART-ADAPT project to automatically de-identify patient waveform and clinical data.

Materials and Methods
ANCA is able to automatically process three types of clinical data: discrete data from the local patient information system (e.g. patient profile, ward round entries), minute resolution summary-measure data from monitoring equipment (e.g. BPs, BPm, BPd), and continuously collected waveform resolution physiological data (e.g. ICP). A configuration is set to determine which data fields should be: removed, generalised or encoded. ANCA then transfers the de-identified data to a cloud-based provider or stores the data locally.

Key Results
The evaluation was performed on discrete, continuous and waveform data from 15 Neurointensive care patients. The data consisted of 2934 files (21.7MB). 20 field types, specifically addressed in the 2013 NHS England Caldicott Review were identified for removal, generalization or encoding (Table 1). Files were randomly sampled and compared pre and post processing by ANCA. De-identification was considered successful if processed as specified. From the test data, an overall success rate of 100% was achieved.

Conclusion
ANCA is a viable tool for de-identification of Neurointensive care data. Although ANCA has been evaluated using criterion defined by NHS England, the tool is configurable to comply with different privacy regulations and is platform agnostic, enabling it to be applied to data captured from a number of manufacturers of monitoring equipment.
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Table 1 – De-Identification Specification (2013 NHS England Caldicott Review) & Results
Phantom study on the effect of CT zone maps on quantitative results with Siemens xSPECT Quant

Alastair Gemmell¹, Carolyn Paterson¹, Alice Nicol¹

¹Department of Nuclear Medicine, Queen Elizabeth University Hospital

Background
Attenuation correction (AC) is essential for quantitative SPECT (1). Siemens xSPECT Quant reconstruction package (Erlangen Germany) uses CT data to apply AC and also to delineate tissue boundaries, creating zone maps for reconstruction (2,3). This study aimed to evaluate the accuracy of xSPECT Quant with different CT zone maps.

Materials and Methods
A Jaszczak phantom (Data Spectrum, Durham USA) fitted with hollow spheres was filled with radioactivity of a known concentration. Iodinated contrast was used to simulate the attenuation of cancellous bone. Images were reconstructed with xSPECT Quant using various CT zone map options. SUVs were produced in the Siemens Volumetrix package by drawing VOIs around the sphere borders on CT. The measured SUVs were compared to the expected SUV, and recovery coefficient curves plotted against sphere volume.

Key Results
Zone map choice was found to have an effect on recovery coefficient, and hence the quantitative result. For spheres containing contrast, the skeletal zone map and SUVavg resulted in recovery coefficients approximating expected results. However, for spheres without contrast the water phantom zone map & SUVmax were closer to expected values.

Conclusion
Further work is required to determine the most appropriate SUV metric for SPECT quantification in different tissue types. Appropriate selection of zone map options is important for achieving accurate results.

References
Identification and Measurement of Long-lived Radioactive Waste produced in the PET Radiopharmaceutical Production Unit

King Wai Yeung\textsuperscript{1}, David O’Donnell\textsuperscript{2}, Sue Champion\textsuperscript{3}, Michael Watt\textsuperscript{4}, Sally Pimlott\textsuperscript{3}, Jonathan Owens\textsuperscript{3}

\textsuperscript{1}Dept of Clinical Physics, University of Glasgow
\textsuperscript{2}School of Engineering and Computing, University of West of Scotland
\textsuperscript{3}PET-RPU, West of Scotland PET centre, Gartnavel General Hospital
\textsuperscript{4}Health Physics, Gartnavel Royal Hospital

Background
During the cyclotron synthesis of $^{18}$F a number of long-lived radionuclide impurities are produced depending on the target body and target foil utilised. These are removed from the final radiopharmaceutical products, thus generating waste containing long-lived radionuclide contaminants. This in turn leads to accumulation of radioactive waste which it is necessary to characterise and quantify prior to disposal. This poster describes our work to identify and quantify these long lived contaminants, and to assess the radionuclide purity of our $^{18}$F-FDG product.

Materials and Methods
A number of different types of samples were measured using a high purity germanium detector:-
- Anion exchange (QMA) cartridge used to trap the $^{18}$F
- Recovered enriched water from the $^{18}$F-FDG cassette
- Final $^{18}$F-FDG product

![Figure 1: A representative spectrum](image)

Samples were placed directly in front of the detector window at a distance of 15 cm and counted for 24 hours with a dead time less than 4%. The operational range of the detector used in this study was about 40 to 3350 keV. The captured spectra were then analyzed by using a free spectrum analysis software called TV. The spectral peaks were identified manually on the basis of their characteristic gamma ray emissions (Figure 1).

Key Results
Twelve different radionuclides ($^{51}$Cr, $^{52}$Mn, $^{54}$Mn, $^{55}$Co, $^{56}$Co, $^{57}$Co, $^{58}$Co, $^{95}$Tc, $^{95m}$Tc, $^{96}$Tc, $^{109}$Cd and $^{181}$Re) were identified on the QMA cartridges and seven radionuclides ($^{52}$Mn, $^{57}$Ni, $^{55}$Co, $^{56}$Co, $^{57}$Co, $^{58}$Co, and $^{109}$Cd) were detected in the recovered enriched water.

Modeling of accumulation of these samples (taking into account decay of each radionuclide and assuming 1 production per day) found that for both QMA and recovered enriched water samples:-
- The total activity of the $^{109}$Cd continued to increase after 200 productions, due to its long half-life ($t_{1/2}=461$ days).
- Activities of the other radionuclides identified all flatten out after less than 200 productions.

No gamma-emitting radionuclidian impurities were detected in the final $^{18}$F-FDG product. The only detected spectral peak was at the energy $510 \pm 0.074$ keV, which is the energy of the $^{18}$F positron annihilation.

Conclusion
- The radionuclide contaminants present on the QMA cartridge and in the recovered enriched water have been identified and quantified.
- Of these, $^{109}$Cd makes the largest contribution to total activity over time for both samples
- No radionuclide impurities were detected in the samples of final $^{18}$F-FDG product.
- The radionuclide purity of the final $^{18}$F-FDG product is approximately 99.99993445% which successfully meets the QC purity requirements, published by the European Pharmacopeia.

Acknowledgements
This work was completed with help from all the technical staff at the PET RPU.
Mobile Enabled Track and Trigger System (METTS) for the National Early Warning Score

Paul Britten\textsuperscript{1,2}, Stephen Dacombe\textsuperscript{2}, Prof. David Keating\textsuperscript{2}, Alexander J. Weir\textsuperscript{2}

\textsuperscript{1}MSc by Research (MVLS), University of Glasgow
\textsuperscript{2}Medical Devices Unit, Dept. of Clinical Physics and Bioengineering, West Glasgow Ambulatory Care Hospital, G3 8SJ, UK

Background

The NHS NICE Guidelines for Acute illness in adults in hospital: recognizing and responding to deterioration \cite{1}, outlines practical guidance with recommendations for the measurement and recording of a set of physiological observations that are linked to a 'track and trigger' system.

One of the NICE research recommendations is:

"What is the clinical effectiveness and cost effectiveness of automated (electronic) monitoring systems compared with manual recording systems in identifying people at risk of clinical deterioration in general hospital ward settings?"

Scottish Government produced the guidance document SIGN139: Care of deteriorating patients \cite{2} in response to the Cabinet Secretary for Health and Wellbeing in June 2012 setting new aims for acute adult health care in NHS Scotland including a 20% reduction in Hospital Standardized Mortality Rates (HSMR) and that 95% of patients should be free from avoidable harm.

SIGN 139 recommends:

"acute hospitals should consider the introduction of electronic track, trigger and alert system."

Both documents recommend the minimum physiological observations are; i) heart rate, ii) respiratory rate, iii) blood pressure, iv) level of consciousness, v) oxygen saturation and vi) temperature.

The Medical Devices Unit has an aim to design a wearable technology platform that can monitor patients wellbeing in a hospital or homely setting which can monitor these physiological observations and perform as an automated electronic 'track and trigger' system. This will be achieved by; i) Identifying the technologies required to monitor the physiological observations required to meet the guidance documents. ii) Ensuring that identified technologies are capable of reproducing equivalent measurements compared to current hospital patient monitoring devices but within a discreet piece of wearable technology.

Materials and Methods

This overall project will be divided into several smaller projects to achieve the final aim. Each step will be designed to have a function that can be built upon to achieve the complete range of patient physiological observations for the Mobile Enabled Track and Trigger System (METTS).

The first of these projects will follow on from work done at the Department of Clinical Physics and Bioengineering’s Medical Devices Unit on Photoplethysmogram (PPG) technology; the aim of this MSc project by research is to produce a prototype of a discreet wearable medical device that can achieve equivalent measurements compared to a bench top medical device for monitoring the following physiological parameters; i) Optical Heart Rate Monitoring and ii) Pulse Oximetry (SpO2 Measurement).

This project will utilise the Texas Instruments Analogue Front End 4404 Evaluation Module with a 3D printed cradle setup to allow the sensor board to be anchored from the ear to have the sensors positioned on the neck behind the jawbone. A second identical Texas Instruments Analogue Front End 4404 Evaluation Module with a 3D printed wrist casing will also be setup to monitor simultaneously with the first. These will then be compared to a bed side SpO2 monitor to ascertain the accuracy of the measurements.
Conclusions
From the success of the work completed by Cat MacLeod on a proof of concept for developing a wearable pulse oximeter, this project will work towards developing a prototype for a wearable pulse oximeter to be anchored at the ear.

References


Consequences of 18F-FDG extravasation
C. Findlay, S. Allwood-Spiers, C. McKeown, G. Gillen

Aim
Extravasation of 18F-FDG can cause image artefacts and localised tissue dose, potentially leading to tissue necrosis. A retrospective analysis of 35 patients who had tissue injections was made to quantify activity and localised tissue dose to the injection site.

Methods
Thirty-five patients with tissue injections were analysed. The radioactivity present at the extravasation site was quantified and tissue dose calculated using the specific dose factor for 18F.

Results
Radioactivity within the injection site ranged from 0.09 MBq to 186 MBq (mean = 43 MBq). Tissue doses ranged between 10 mGy to 1.1 Gy (mean = 284 mGy).

Of the 35 cases, 15 patients had more than 10% of the injected activity at the extravasation site. In most cases where a high activity was tissueed, the activity was spread over a large volume and so the localised tissue dose received was not high.

The highest dose received from a tissue injection from this sample, estimated at 1.1 Gy, which is below the level at which erythema is likely to occur. Deterministic effects of radiation on the skin are expected to occur from a dose of 2Gy upwards [1].

Conclusions
Evidence from this patient sample has shown that despite what can sometimes be striking appearances on patient images, the dose from 18F-FDG tissueed injections is unlikely to result in tissue necrosis.

Neonatal Motion Sensing

Stephen Dacombe¹, Richard Boulton², Tom Waterhouse¹

¹Dept of Clinical Physics & Bioengineering, Medical Devices Unit, West Glasgow Ambulatory Care Hospital
²Dept of Clinical Physics & Bioengineering, Princess Royal Maternity Hospital

Background
In our work, motion sensing will be integrated with a neonatal pulse oximeter in order to classify the relative movement of the pulse oximeter over a 24 hour period. The knowledge of movement, proximity of the sensor to the skin and ambient light conditions can be used to ascertain whether recorded oxygen desaturations and spikes or troughs in heart rate are likely to be the result of movement artefact or true desaturations and changes in heart rate, thus enabling a fuller picture of the neonate’s health. The sensors used are:

i. 3 Axis Accelerometer
ii. 3 Axis Gyroscope
iii. 3 Axis Magnetometer
iv. Temperature Sensor
v. Proximity Sensor
vi. Ambient Light Sensor

Some neonates are sent home with standard neonatal pulse oximeters for 24 hour monitoring. The 24 hour recorded data is then analysed and feeds into the overall clinical picture as to whether the infant is well enough to stay at home. The parents are requested to keep a diary of events like feeding, sleeping, disturbance etc.

It is well known that all Photoplethysmography (PPG) systems suffer from movement artefact. Masimo appear to have a system that is the most resilient to movement artefact. Currently the Perfusion Index (PI) is used as a pseudo movement artefact indicator. When the Perfusion Index is artificially high, then the desaturations are ignored. Note recorded Heart Rate will also be affected.

The system in development is initially to be used to assess whether the current methods are suitable and to ascertain whether the extra movement/proximity data can be useful for the clinician.

Materials and Methods
The development system is based around an Arduino Zero development board. There is a SD Card based Datalogger shield, a custom designed sensor board and cable (Medical Devices Unit) and a custom designed data visualisation tool (Medical Devices Unit). The Masimo Radical 7 monitor, transmits parameters (Time stamp, HR, SpO2, PI, PVI and various alarm conditions) over a RS232 port every second. The Masimo data is just a snapshot, every second, of what the monitor is displaying. This data is read into the Arduino and then written to the SD card along with the Time stamp of the Datalogger, the motion data, the temperature data, the proximity data and the ambient light data. The development system uses standard AA batteries and can record for approximately 30 hours. Custom data visualisation software is being developed to visualise all of the data in an intelligent way.

Key Results
Experience with commercial pulse oximeters has indicated that during motion, the pulse oximeter should be ignored. However, it is unclear how long after motion (there is no definition of motion) the effects are seen in the displayed Heart Rate and SpO2. When the infant is sent home, knowledge of movement is lost, therefore providing a system to record this data will be very useful.

To our knowledge no real independent research has been undertaken to assess the vulnerabilities of pulse oximeters during motion and whether they should be trusted. The system is on track to record all of the information and to display the data in a helpful way.
Conclusion
The system is initially to be used in a research capacity to better understand the benefits of the system. If successful, the system will be used in a clinical trial. The system could be enhanced and integrated into medical grade wearables.

References
See poster.

Assessment of Mechanical Dyssynchrony of Ventricular Contraction in Rest and Stress RNVG
Mominah Waseem¹, K. Jones², C.A. Paterson³, W. Martin⁴, N.E.R. Goodfield⁵
¹Nuclear Cardiology, NHS Greater Glasgow and Clyde, UK

Background
Radionuclide Ventriculography (RNVG) is a technique used to assess cardiac ventricular function, and can be useful in determining prognostic information. This imaging technique involves technetium-99m (Tc-99m) - a radionuclide that emits 140keV gamma rays and is labelled to red blood cells to image the blood within the ventricles. The aim of this research project is to analyse data obtained from stress and rest RNVG scans, for patients with breathlessness and preserved systolic function according to echocardiography results, and determine whether their symptoms could be due to dyssynchrony of the heart. Values for synchrony (S) and entropy (E) were calculated, in order to assess dyssynchrony. Synchrony illustrates the difference in onset of contraction within chambers of the heart, whereas entropy quantifies the disorder within a region of interest (ROI)[1].

Materials and Methods
The first patient group consisted of 52 clinical gated planar list-mode RNVG studies. The patients involved were imaged at two positions of rest: supine, where the patient was lying flat and erect, where the patient was in erect position. The patients were then stressed to two increasing levels of exercise, where level 1 involved unladen bicycle exercise and level 2 consisted of 25W of bicycle exercise.

The second group of patients consisted of 100 clinical gated planar list-mode normal RNVG studies, taken from patients with no known cardiac disease (QRS < 120 ms, normal myocardial perfusion scan, normal RNVG scan, normal EF). A normal range was calculated using this data for both synchrony and entropy parameters.

Synchrony and entropy parameters were calculated from phase values extracted from the first order Fourier harmonic fit to the RNVG time-activity curve. The phase and amplitude values where then processed using a matlab code, to define parameter values.

Key Results
It can be seen in Figures 1 and 2 that as exercise increases; the average values of synchrony decrease and entropy values increase; indicating an increase in dyssynchrony with stress. It can also be seen that the heart is less dyssynchronous when the patient is in erect position in comparison to when in supine position. Interestingly, there is a significant difference between synchrony and entropy values at the two different rest positions; this may be due to physiological changes.

Conclusion
The results have shown that increased exercised induced stress increases left ventricular mechanical dyssynchrony. Further work will include subdividing the group by level of ischaemia and investigating additional parameters such as approximate entropy and sample entropy. In particular, in patients without evidence of significant ischaemia, the hypothesis that their breathlessness can be due to increased mechanical dyssynchrony of ventricular contraction at stress will be assessed.

References
Figure 1 – A boxplot graph showing the change in synchrony across the different levels of exercise, where the blue points are the mean values, whiskers show maximum and minimum values excluding outliers and the box is the upper quartile, lower quartile and median.

Figure 2 – A boxplot graph showing the change in entropy across the different levels of exercise, where the green points are the mean values, whiskers show maximum and minimum values excluding outliers and the box is the upper quartile, lower quartile and median.