ARTP
Association for Respiratory Technology & Physiology

INSPIRE

August 2024
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Issue 2

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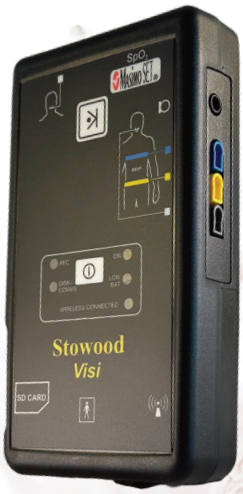

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ALL ARTP CORRESPONDENCE TO:

ARTP Administrator,
Executive Business Support Ltd.,
Unit E1 City Wharf,
Davidson Road,
Lichfield,
Staffordshire WS14 9DZ
Tel: 01543 442141
Fax: 0121 355 2420
e-mail: admin@artp.org.uk

ENQUIRIES TO THE EDITOR or ARTICLES FOR SUBMISSION:
Please contact the Editor, at Inspire@artp.org.uk

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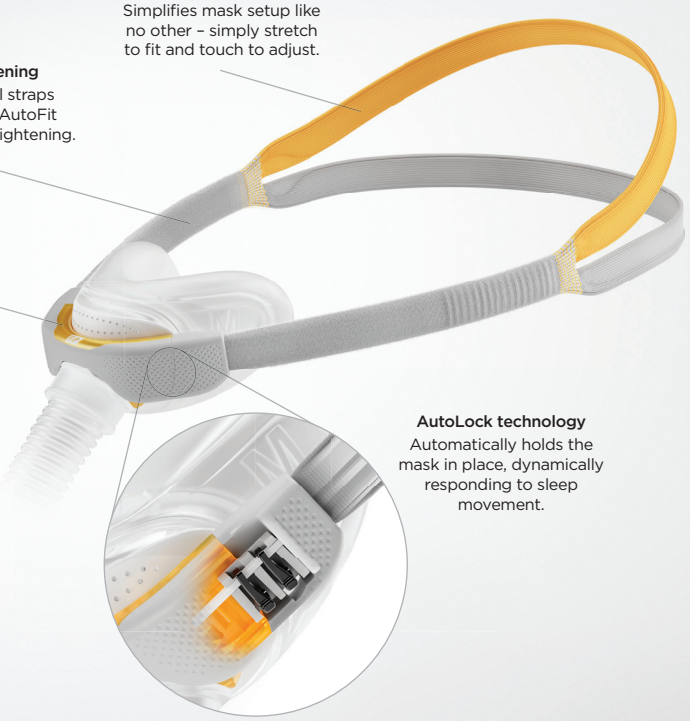

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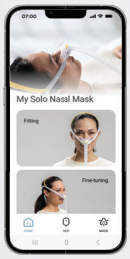

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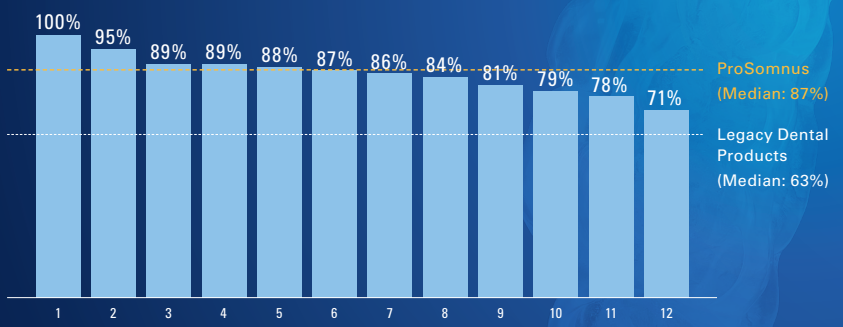

1 Charkhandeh et al. JDSM 2017
2 Silva et al. Abstract – World Sleep Congress 2023
3 Stern et al. Cureus 2021
4 Smith et al. Abstract – World Sleep Congress 2022
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9 Mosca et al. JCSM 2022
10 Braem. Abstract – iBEDSSMA 2023
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First word

Dear Readers,

Welcome to the summer edition of *INSPIRE*. If you were lucky enough to have attended the conference in Harrogate, you will have enjoyed some excellent talks and you may also be aware of some changes within the ARTP committees. The two main ones are we now have a new chair and vice chair. Joanna Shakespeare and Matthew Rutter are now at the helm and as Joanna mentions in her first word, they have already been busy making improvements. A big thanks to Dr Julie Lloyd for all her hard work as chair over the last few years. I have worked with both Jo and Matt on previous committee roles within ARTP and therefore know the organisation is in good hands. We have included a section on '**Getting to know the ARTP Committee Chairs**' with Joanna and Matt described in detail and web links to the others.

If you weren't lucky enough to attend conference, you can catch up with all the respiratory abstracts in this publication. The sleep abstracts will be published in the upcoming *S-News*. The plan will also be to approach the authors of some of the best pieces of work and ask them to write up a full article for a future edition of *INSPIRE* and *S-News*.

This edition also sees an '**In Memory**' section dedicated to our late and much loved colleague, Nick Chapman. Many thanks to his wife Ali, for providing the information on Nick's career. '**Lab in the Limelight**' travels across the Irish sea to county Fermanagh, Northern Ireland, for an insight into Lisa McManus's lab. '**Respiratory Life Stories**' has a fascinating account of the career of our very own former *INSPIRE* editor, Aidan Laverty. The research committee have provided their regular instalment of '**Fresh Air**', which is an article very much in my area, looking at the use of CPET to diagnose dysfunctional breathing in paediatric patients. We also have an interesting article on potential errors when looking for bronchodilator responsiveness in emphysema.

I hope you enjoy reading this edition as much as I have and as always, thanks to the all the contributors to this edition and the editorial committee who have worked hard to proof read and check all the articles. If you would like to submit your work or have any suggestions for future editions please do not hesitate to contact me.

Paul Burns
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A Word from the Chair

Dr Joanna Shakespeare, *ARTP Honorary Chair*

Hello and welcome to this edition of *INSPIRE*, my first as ARTP Chair. As I write this, I am preparing for my summer holidays and hope that you all get to spend some time away from work and that wherever you are, you get to enjoy some well-deserved sunshine and rest.

It has been a busy few months since I took over the Chair role and I have certainly had to hit the ground running. Matt Rutter and I have been using our IQIPS experience to good effect. We are implementing a document management system to support the ARTP Secretary, Sara McArthur. This has seen us review and amend the Terms of Reference (TOR-s) for the ARTP Council and Executive Board. As a result, the Spirometry committee now sits directly on Executive Board as an independent committee rather than a subcommittee of Education. The workload for both the Spirometry and Education Committees is immense and it seemed more sensible to split them. We have also updated the membership code of conduct and the complaints procedure. We are launching standards for the membership and corporate members, which will be distributed shortly. We are in the process of ensuring that all Chairs and Vice Chairs have job descriptions and that TORs for all committees have been reviewed.

We are very aware that there have been lots of new changes to roles on ARTP committees and if you are following us on social media, you will have seen a series of 'Introducing you to' messages. These were aimed at giving the membership an insight into who we are and what our aspirations are within our new ARTP roles. For those not on social media we have included a link to the introductions within this edition of *INSPIRE*.

The ARTP Conference 2024 in Harrogate was a huge success. It saw us move away from our historical hotel-based venue into a much larger conference centre which was necessary due to the continual growth in both delegate and manufacturer numbers. For those of you in attendance, I am sure that you would agree that the manufacturers' exhibition was much better for being in a large, open space. We are currently working hard on planning for the National Strategy Day and also conferences for both 2025 and 2026 (our 50th anniversary.) The feedback from this year was a resounding preference for a conference-type venue moving forwards which will also enable us to continue to grow. We will also be using the feedback we received to plan the agenda for next year's conference. We are very close to finalising the venue and dates for 2025 so watch out for an imminent announcement.

Conference also gave us an opportunity to raise awareness of the wide variety of roles within ARTP and current vacancies. We had an excellent response with many committees now fully subscribed and it is great to see lots of new faces. We are, as ever, thankful for all of the hard work ARTP members put into their roles and responsibilities within ARTP as without them the professional body would not function. There are further new roles to be advertised shortly and so please put yourself forward if you would like to be involved. If you

would prefer to just ‘dip your toe’ initially rather than fully commit, then watch out for the ARTP membership projects soon to be launched by Matt.

June saw the sad news of Nick Chapman’s death after a short and brave battle with cancer. I was personally devastated by the news. I have known and worked with Nick for many years, and I saw him very much as a friend as well as a colleague. We are grateful to Nick’s wife Ali for supporting us in writing an ‘In Memory’ which describes Nick’s career within health care. We continue to send our thoughts and best wishes to Ali and their children, James and Lewis, and to all his colleagues at Medical Graphics. He will be greatly missed.

As I start my journey as ARTP Chair, I would encourage members to communicate with myself (chair@artp.org.uk) or specific Committee Chairs (via admin@artp.org.uk) as much as possible. We are keen to ensure that we continually engage with the membership so that we can be the best representatives of the professional body that we can. I will leave you now to enjoy this edition of *INSPIRE* and wish you a wonderful summer whatever you may be doing.

In Memory of Nick Chapman

At the beginning of June, ARTP received the terribly sad news that we had lost one of our colleagues and friends. Nick passed after a short illness at the beginning of June. He was the managing director of Medical Graphics UK and was well known to many ARTP members due to the company's standing and success. At such a young age of 48 and with so much left to give, this news has hit the ARTP hard. Despite knowing his prognosis, we were delighted to see Nick attend the conference in Harrogate at the end of April to see and catch up with many of his friends and colleagues for one last time. This showed tremendous resilience and bravery which was also evident when you look back on his career. Below is an overview of Nick's career and some testimonials from customers and colleagues.

Nick started as an apprentice engineer at Beaver Medical Products in 1994. This was his first role in the profession on leaving school. This was based in Northampton and consisted of a two year Higher National Diploma in Electronics. One of Nick's placements was at Good Hope Hospital in Birmingham in 1996, which allowed him to gain valuable experience in medical engineering and the inner workings of a hospital and NHS environment.

The following year, his apprenticeship was complete and the work of a fully-fledged service engineer for Beaver Medical began. Nick had a desire to learn, and therefore, wanted to go beyond the standard engineering duties of fixing problems; he wanted to understand the clinical application side so he could better relate to his customer's needs and provide them with the best service and products possible. It was this trait along with his love of sport that led him to suggest that they create a dedicated team to work on and sell the MGC cardiorespiratory diagnostic products. Nick recognised the loyalty that Beaver Medical had shown by giving him his opportunity so he wanted to develop and enhance the success of the company to repay this. The company allowed Nick to lead this and it was very successful. However, in 2007 Beaver Medical went through an acquisition and Nick was made redundant.

Adrian Hunt, Martin Yaconis and Nick at ARTP conference in Glasgow

The passion Nick had for his work meant he was determined to continue in the field of cardiorespiratory diagnostics. Medical Graphics, who were based in the USA, were impressed with the work Nick had done selling their product whilst with Beaver Medical, therefore they were keen for him to continue this. In order to do so, Nick brought his wife, Ali, on board. Ali came from a career in the banking industry and was able to bring essential finance, administration and system-processing skills. Alongside her, Nick recruited the skilled engineers and IT specialists: Adrian Hunt and Howard Murphy. Alas, Medical Graphics UK Ltd was born in 2007.

Nick always put the customer first and knew the importance of getting it right. He was dedicated to the job, professional and always very respectful. He was a great listener and always took time to chat with his

customers to try and improve company service. Nick loved his job and regarded many of his customers as friends which made it feel like he wasn't actually working whilst doing the great job he did. For these reasons, Medgraphics UK are still going strong as one of the leading competitors for cardiorespiratory diagnostics in the UK, with a team of eleven – all sharing the same original goal from 2007: focusing on customer service above everything else.

Nick is survived by his wife, Ali and his two sons, James and Lewis. We are grateful for the friendship, time and service he gave to the profession.

Below are some memories and comments from customers and colleagues.

It was a great shock to learn of Nick's incredibly short illness and passing. Nick was someone who, from the minute you met him, felt like a friend. He had a great sense of fun and a smile for everyone. Grounded, respected and knowledgeable; he led a fabulous small team who seemed more like family than colleagues and I have no doubt his professional success was tantamount to his personable approach with his customers. He took genuine interest and care for his customers and pride in his company. He always spoke with love and pride about his family. To them and his close colleagues I pass on my most sincere condolences for the loss of such a genuine character.

Claire Fotheringham, *NHS Lothian*

I first met Nick about 20 years ago while I was at King's College in London. He was demoing some CPET equipment for the cardiology service. He was very knowledgeable about the system and completely transparent and honest in his delivery. I remember ribbing him about his West Country accent and with my Dad being from Devon it sounded very familiar. Different times...

Fast forward about ten years and then our paths crossed again as our equipment was due for replacement. The transparency and openness was evident again. We didn't choose Medgraphics on this occasion but it was clear how successful Nick and his team had become with Nick leading from the front.

Fast forward again about another 5 years and I got to know Nick more and more over the last few years through supporting various CPET courses, ARTP and others in Ireland (including a free Dublin bus ride, but this was more down to Dr Shakespeare), plus Nick supporting our procurement of filters and oscillometers. He often spoke with pride about his boys, playing rugby, how he wanted to be on the same field as them so badly and how he was still the fastest on his team despite his age! We joked that I knew what position he played given the state of one of his ears. Also that his position meant he could be the disruptor of the oppositions' plays. I always knew this suited Nick's personality to a tee. I enjoyed Nick's company immensely. I am gutted that he has left us too soon. My thoughts go to Ali, his boys, all their family, Ollie, Ade, Alex and all the team at Medgraphics.

Dr Karl Sylvester

Nick had great character. He was an honest man who was always enjoyable to be around. He was knowledgeable and always did his best to support the NHS and bridge the gaps between industry and healthcare, finding ways to work in partnership for the benefit of patient care. I was fortunate to get to know Nick on a personal level, and enjoyed many conversations with him about family, friends and anything other than work. Nick will be dearly missed but his memory, I am sure, will live on, not just here at Coventry but in many other places and with many other people.

Ed Parkes, *University Hospitals Coventry & Warwickshire*

Getting to know your ARTP committee chairs

Who am I?

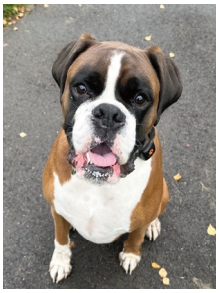
I am a Consultant Clinical Scientist at UHCW NHS Trust in Coventry. I started as a trainee physiologist in 1994 in Birmingham and developed under the leadership of Prof Dame Sue Hill and Prof Brendan Cooper. In 2006 I left and moved to Coventry as the Head of Service. In this role I was able to develop and expand the services and the team and led the service to achieve IQIPS accreditation in 2016, the first Respiratory and Sleep service to do so.

Following completion of the HSST programme I moved into a Consultant Scientist role and now deliver sleep and ventilation clinics with the occasional CPET clinic to maintain my skills.

A bit about me

I like to think that I am organised, a big help when it came to achieving our IQIPS accreditation. My other personality traits would include being open, honest and dedicated. I am passionate about raising the profile of healthcare scientists and doing what I can to support others to achieve their goals.

I have experience of ARTP committees having spent several years on the Education Committee as Examinations Chair, Education Vice Chair and Chair before moving to the ARTP Vice Chair role. I was also the Lead Editor for the STP Curriculum Review (Respiratory and Sleep).



Personally, I am mum (or mom as we say in Birmingham) to teenage twin boys and one Boxer dog (photo included for effect). I am a season ticket holder at Aston Villa FC and currently living the dream whilst it lasts! I like to keep fit and throw in the odd endurance event every now and then to keep me motivated.

What would you like to achieve in your new role?

One of my boys is autistic and has really struggled in a mainstream school environment. Supporting and navigating my son through school has been a steep learning curve for me and I have implemented a lot of this learning into my working practices.

I would really like to support ARTP to develop its ED&I so that we can be as inclusive and supportive as possible for the benefit of all our members.

Introducing ARTP Board Members

Matthew Rutter – ARTP Vice Chair

Who am I?

I cannot talk about myself as a physiologist without recognising how I got into the role.

Firstly, I have been a patient since 1998 and saw that side of a full lung function test. I later learned the impact of a good physiologist, striving for the results as it had real implications for my treatment. I later went on to focus my education towards working in the department after discussions with my consultant. I started in 2002 and learnt a great deal of performing lung function and physiology from Darren Murray of Vyaire fame, this was developed further by the mentorship of Dr Karl Sylvester of ARTP fame in 2006 onwards.

In 2008 I was awarded the young healthcare scientist of the year and I have tried to live up to the expectations that come with this. In 2014, I was granted an NIHR Fellowship to do a Masters in Clinical Research at Kings College London.

These experiences have led me to becoming the lead at Cambridge University Hospital, attain IQIPS accreditation for the service and drive to do more within the profession. I am really lucky that in my time at CUH, I have come across many great people to work with.

A bit about me

I think my main qualities are that I am a problem solver, I have a lot of ideas and I constantly want to improve in all aspects of my professional role. I am also a perfectionist, I like to be in control and I like to take the time to gather and consider information. I am also a people person, which is ideal for a patient facing role, although I can often have a long chat with regular patients!

From 2015 I was the manufacturer liaison for ARTP, it was a great experience to be in such a pivotal role working with ARTP's main supporters. The role required my involvement with many different ARTP committees and this meant I could have a positive impact in many different areas. I set myself high standards and quality is very important, so it was only right that I ended up on the standards committee!

Outside of work I regularly cook and have a slight pasta addiction (I should have been Italian). I am a bit of a film/TV buff too and I think this comes across often in my sense of humour and creative side.

What would you like to achieve in your new role?

I think ARTP gets a lot of things right, there is a positive attitude and enthusiasm for the work we do. I can see areas for improvement within ARTP and also the profession.

Being able to support and develop the work of ARTP has been a positive experience and therefore, I would like to get more of the membership involved, either through ARTP committees or projects.

Follow the links below to see information on all of your committee chairs and vice chairs.

Dr Joanna Shakespeare – ARTP Honorary Chair
Matthew Rutter – ARTP Vice Chair
Andrew Pritchard – Standards Chair
Joanna Purvis – Standards Vice Chair
Helen Purcell – Education Chair
Marie Belcher – Education Vice Chair
Mark Unstead – Examinations Chair
Claire Francis – Spirometry Chair
Chris Harding – Spirometry Vice Chair
Andrew Morley – Sleep Chair
Edward Parkes – Sleep Vice Chair
Laura Jess – Events Chair
Colleen Carden – Events Vice Chair
Emma Fettes – Paediatric Chair
Philip Lawrence – Paediatric Vice Chair
Natalie Goodwin – Communications Chair
Max Thomas – Workforce Chair

The rest of the ARTP Board will be introduced in the coming weeks.
You can also click **here** to see all the different ARTP Committees and the members within.

Physiologist life Stories

For this edition of respiratory/physiologist life stories I managed to talk Aidan Laverty into giving me an opportunity to delve into his career and life. Aidan will be best known for being at the helm of the respiratory and sleep physiology lab in the most prominent children's hospital in the UK – Great Ormond Street Hospital (GOSH). He may also be familiar to ARTP members as he was my predecessor and edited Inspire for the best part of 11 years.

I first met Aidan at the ERS conference in Vienna in 2012. We quickly became friends and this followed up with meeting at the ARTP conference in Hinckley in 2012. At this point Aidan took over editing Inspire and roped me into helping him as deputy editor (although I wasn't much of a help!). Being new to paediatrics at this time I leaned on Aidan for lots of advice and some trips down to GOSH.

I want to thank Aidan for giving up his time at short notice. A couple of things that struck me on doing this interview: Aidan's IT skills combined with being a physiologist have done so much for the departments he has worked in. It was fascinating to hear how he took his department from doing lung function tests with no computers to being fully digitalised with databasing capabilities without the help of manufacturers. He is very modest which came across in this interview and some of his answers don't do him full justice.

We actually met in London for a bite to eat and a few drinks several weeks ago prior to me teaching at the ARTP lung function reporting course in Reading. Unfortunately, I had not planned it out very well so never got round to interviewing him face to face. Instead we spent an enjoyable couple of hours chatting over Microsoft Teams a few weeks later.

Tell me how you ended up working in respiratory physiology?

I left school at 18 after doing my A-levels and applied unsuccessfully for jobs including an operating department assistant plus at a chemical lab in West London. Then I saw a job advertised in the London Evening News for a MPPM (medical physics and physiological measurement) technician. They were looking for a student that had five O levels with maths and English. I did not know anything about this post, but I did do biology, chemistry and physics at school so obviously had some sort of scientific intent!

Where was the job based and what did it involve?

It was a training scheme based jointly between the Brook General hospital, in southeast London, near Greenwich and also Guy's Hospital in central London. Initially you did two years of an Ordinary National Certificate (ONC) in MPPM while on rotation across various diagnostic services. This involved six months at the Brook doing respiratory and cardiology then Guy's for a year doing a mix of perfusion, intensive care, biomedical engineering, dialysis, audiology and neurology. At the end of eighteen months I had to choose a discipline to specialise in and I chose lung function at the Brook for two main reasons: I really enjoyed the patient contact involved in lung function, which I felt was more involved than in the other disciplines. The other reason was a man called Bob Burns, who was heading the lung function department and was in his late fifties when I met him. He was writing software and applying it to respiratory testing. I had never seen a computer before! He introduced me to writing programs, initially onto a TI-59 programmable calculator and I ended up writing exercise test predicted equations on it.

After completing my ONC, I had to do two more years of a higher national certificate (HNC). For this I had to complete a project. Bob advised me to write software to compare volume measurements between a pneumotach and a Parkinson Cowan gas meter and evaluate how both reacted with different flow rates. I used a RM 380Z computer with A-D card and FORTRAN language to do this. The project also introduced me to using statistics to compare the devices.

What equipment were you using in the lab at this point?

It was 1983, so we used a wedge bellows spirometer. We also had a rolling-seal spirometer, helium dilution and standard PKM for gas transfer. When we measured body plethysmography, the transducers and pneumotach were linked to an X-Y recorder and if you needed a flow volume loop you had to rejig the input channels for the X-Y recorder. At this time, the lab was switching to full computerisation so the X-Y recorder was on the way out and we eventually added CPET, with a mass spectrometer linked to the computer, all with custom built software. The mass spec took up most of one wall of the room! I recall another use of it was for hyperventilation screening. Other more 'exotic' tests included mixed venous PCO2 and allergic precipitins.

What happened after the training period?

A job wasn't guaranteed after the initial two years of training, however £194 a month and cheap accommodation was a 'perk', I realised many years later. The Brook offered me a post and I remained there for five more years, becoming a Senior Physiologist.

You are best known for leading GOSH. How did you end up working there?

In mid-1988 I started to become a bit restless and needed a new challenge. Something told me it was time to move on and I saw a Chief Physiologist post advertised at GOSH which I think may have been advertised in Inspire (probably 'Breathe'), funnily enough! I applied and got an interview and on the same day as my interview I was doing my final Open University exam just around the corner from GOSH. So, I did the exam then popped across the road for my interview.

Tell me about your time at GOSH.

The lung function lab was providing a limited service when I started. There was one other physiologist, who was a locum and performed a standard range of tests, minus plethysmography. There were no computers in the lab and it seemed a little behind compared to where I had come from. They had a bodybox and there was an X-Y recorder and amplifiers all mothballed in a store room, so this had previously been used but the expertise had been lost, I imagine. The aim was to build the lung function service. Through my experience gained at the Brook and with the help of biomedical engineering I got it all up and running. As this was happening, I purchased my first PC for the department for £1500 (a 286 AT) and to me it seemed like the greatest computer ever. It was much faster than anything I had previously used at the Brook. I developed a computer database that held all the patient results and allowed calculation of TGV from input of the X-Y recorder measurements (including protractor measured angle from the X-Y plot). I recruited two more physiologists in 1989 so we now had three in the team providing full lung function.

A few years on from this, the infant lung function team led by Janet Stocks were using a computer software program named 'RASP' for use in infant lung function plethysmography and over time the paediatric laboratory adopted this. Infant lung function was situated in an adjacent lab, initially as part of the Institute of Child Health research team, but eventually this also became a clinical service.

How did the department evolve to encompass sleep?

Rod Lane arrived from Charing Cross Hospital as a lecturer a few years after me. He brought research expertise in lung function, including introducing CPET and was instrumental in starting the sleep lab, initially as an offshoot of lung function. There was existing software, developed in-house, which allowed download of data from an oximeter via a RS232 serial port so I adopted the idea and wrote new code which allowed us to download overnight oximetry data plus transcutaneous CO2. We started using CPAP/NIV with patients around 1993. At this time I wrote a sleep database which stored all the oximetry data. This was similar to the lung function database but as the sleep service grew I realised we had to have something for arranging appointments, reporting sleep studies and one for NIV equipment and settings. So, at one point I had three databases running therefore decided to start again and merge them into the one database, which continued with various improvements until 2019.

GOSH paid for me to do a computer science degree at the University of Greenwich. My project for that was linking a Vitalograph compact spirometer to a PC to store the flow values which would allow me to re-create the flow volume loop whenever required. I integrated this with the main database so the results were imported into it automatically. We also had a portable version of this, used in clinics, which merged into the main database. The software allowed comparison of the best flow volume loops of the patient's three previous visits alongside each other, which I thought was a good way of examining trends and shape changes in the curve over time.

How big was the Department at this point?

There was myself, Rod and the two physiologists recruited in March 1989. I was running the day to day stuff but I had no research expertise. I would say I was Rod's right hand man. He came up with research ideas and I supported him with my physiology, IT and database skills. As sleep got bigger one of the physiologists started to help out more in sleep and we recruited someone else to help cover lung function. Overnight sleep studies were initially supervised by nurses on our respiratory ward but we eventually recruited an experienced sleep physiologist to help

improve the quality of the studies, initially on two nights per week I think. We would set up the sleep systems, wheel them into position and the overnight physiologist would take it from there. This would have been roughly 2006-7. A successful business case allowed the establishment in 2010 of a dedicated sleep unit. We initially had this as one band 6 and one band 3 on overnight duties, working four nights per week with two studies per night. Today we have over twenty staff between sleep and lung function. The sleep lab now functions with three night shift staff running inpatient sleep studies seven nights a week. The NIV service has its own team of Clinical Nurse Specialists now.

You have some very useful IT skills which have helped you and many others in your career. Can you tell me about this?

While at the Brook, I completed two computing courses which were: "TM22 The Digital Computer" and "M252 Computing and Computers" – this shows how sad I am remembering the exact names! The Digital Computer one was more about how a computer actually works, logic gates etc. Computing and Computers was how it all fits into business and networks. The other qualification I did was "T292 Instrumentation", which was very physics-based. This was the toughest exam I ever did and was actually the one I mentioned previously which I had the same day as the GOSH interview - I scraped a pass!

My BSc Computer Science was in 1993 and by the early 2000s I wanted to gain a formal qualification to recognise what I was doing and GOSH funded me to do a MSc in Health Informatics, at London City University. I thought this would be the qualification most useful to help me apply my IT skills to healthcare. What I came to realise was that writing software was only a small part of it and it was more of a business/management type course but it introduced me to neural networks, artificial intelligence and there was a database module. At the time when I was trying to think of a suitable project, I had a vague idea of using PHP/SQL, which I had read about - PHP is a web-based language often used in association with MySQL databases. The GOSH respiratory department worked closely alongside the Institute of Child Health, University College London. There was much interaction between clinical and research staff and as I was walking to my office, I overheard a respiratory consultant, (now Professor Adam Jaffé), saying he wanted some sort of system to log the number of rare orphan lung diseases. He mentioned the British Paediatric Surveillance Unit (BPSU) Green card system. I suggested creating an email response website automatically storing the responses in a database. He took me up on this, which became my MSc project and also a long-running British Paediatric Orphan Lung Disease website, subsequently published. There followed several adaptations of this work, including one in Australia and one specialising in Neurology, my involvement with which has ended only recently. I was glad that the management of these were successfully handed over as maintaining competency in an ever-changing software world was difficult! There have been many software projects, however the scope for these is now limited as manufacturers have improved their offerings and support and additionally, GOSH now has an all encompassing EPR system. More recently I have developed simple websites to assist the sleep and lung function laboratories to manage their documentation.

Talk to me about running a big paediatric service.

The management of the service was something that came upon me unexpectedly and at short notice. It was a steep learning curve! I moved from the day-to-day service provision more to delegation and planning etc. It has grown considerably since my early days both with numbers of patients and staff. It's nice to have been involved at the start and to have had the experience of making mistakes and (hopefully) learning from them. Coming in 'cold' allows the opportunity of asking 'silly' questions (regarding budgets, for example) in genuine ignorance! When I moved from doing less patient-facing and more managerial-type work, I had an initial feeling of guilt that lasted for years! Recently I have reduced my hours to two days per week and again felt I was not able to help as much as I used to. But I have learned to manage it better and prioritise what I should be doing and realising I can help out in other ways. I used to analyse and report on many sleep studies but have become a little rusty and had a recent refresher session, from our understanding Lead Sleep Physiologist, so I could try to help with a reporting backlog! I do miss the clinical work but I am realistic enough now (I think) to know that I am probably not able to do this now, never mind having the time to maintain competency. Another important and nice part of the job is to see new people rising through the ranks and presenting at conferences like ARTP. I now understand that if I am not needed then that is a good sign! I am fortunate to have great service leaders in Emma Fettes and Matthew Davies (lung function and sleep, respectively).

Can you give me some of the Highlights of your career?

Over the years I have been involved in many different projects with many clever people, so I find this difficult to answer. An early highlight was a UK project that Janet Stocks at GOSH undertook in collaboration with the paediatric departments at Leicester and Glasgow, run by Caroline Beardsmore and Jimmy Paton, respectively. This was looking at tracking respiratory function in children who had previously had Extracorporeal Membrane Oxygenation (ECMO). We met in Glasgow with the physiologists. One of the issues was how we were going to coordinate the data and keep track of it all

Some of the UK ECMO trial team. Left to right: Dr Jimmy Paton, Prof Janet Stocks, Dawn Jotham, Aidan Laverty, Caroline King, Cara Oliver, Caroline Beardsmore

so I volunteered to do a database. I remember Janet supported me during the meeting but I am not sure she fully trusted I could do it, but I lived up to my word and several publications resulted.

Another highlight would be when I took part in the young Everest study. A group of us, including Janet and Emma (Fettes), were looking at normal children's responses to hypoxia so as to better understand hypoxia in respiratory and cardiac disease. I wrote a database to allow us to transfer data at different locations (and altitudes) along the way to Namche Bazaar. Many projects, many great colleagues: I don't think Inspire has the room for them! I have been involved with the growth of the lung function, sleep and NIV services at GOSH from the start but there have been many colleagues who have taken these Units forward at different times and made the department what it is.

Can you tell me about me some people who have inspired you throughout your career?

Bob Burns at the Brook got me interested in respiratory physiology and particularly on the use of technology to capture data. He also encouraged me to learn more about electronics to assist with this, but I never grasped that! I have met many good colleagues at GOSH who have helped and inspired me. I don't want to name them as many are still going and will be embarrassed! I definitely need to mention Professor Janet Stocks. When she retired I realised how much she was missed, but don't get me wrong, she told me off a few times! My involvement with ARTP (Inspire) has made me realise how little I know about respiratory physiology - there are some highly knowledgeable people out there!

You have an Irish name and before the hair was gone you were a red head but you have a strong cockney accent. Tell me about your family and background.

I was born in Camden, London in the 60s and my parents met there after travelling from Ireland in the 50s for work. Camden back then was very much an Irish place. We used to go over to Armagh for a six-week holiday each summer. We would travel to Heysham or Holyhead and take the overnight ferry to Belfast, a trip that you and I revisited when the ARTP conference was held there a few years ago! However, I don't actually know that much about Ireland and if I had a check box on my passport it would be ticked as "Londoner".

When I first met you in 2012 you became editor of Inspire and transformed the publication. Had you been involved in the ARTP before that and how did you find it?

I had not really been involved much before that. Rod had been involved and I had helped him with a few things but Inspire was the first real job I did for them. I had spoken with Martyn Bucknall, then ARTP Chair, at the ERS in Vienna and he asked me to edit Inspire.

I enjoyed doing the editing as it's a great way to learn. You find yourself reading articles on topics you previously would not have read. I enjoyed asking people to write articles on various topics. I have a good eye for editing and as you know, I'm still helping out on the editorial committee and have been proofreading the new Part 1 handbook. At the beginning it's nice to introduce new ideas and seek articles on topics that you would like to read but after ten years it becomes more difficult to think up new things.

I know you are a keen footballer and have organised and played with the hospital for many years. Talk to me about your football career.

I played for my primary school and have a medal somewhere but it wasn't a part of my secondary school. When I left school I played one season for Guy's Hospital and played for the Brook Hospital in the 1980s against the "Eastenders", including Ian Beale and Lofty! There have been several weekend pub and veteran teams and also played for GOSH v "Hollyoaks" at Charlton stadium, the Valley. I prefer attacking midfield but can play on either wing. I've been playing at GOSH for the last twenty years and recently gave up organising the Tuesday night football after six years of this - probably more stressful than Inspire! Several recent injuries have led me to conclude my footballing career may be over.

I have been a Manchester United fan since I was young, probably because the club was popular with the Irish in the 1970s, although there was no influence from my father, who prefers Gaelic football. The primary school I attended in Camden had Arsenal as the nearest club so the school was basically 50-50 split, Arsenal v Utd. My brother has ensured my son is a "Gooner" though! My local team is in the Isthmian league so I pay them a visit a few times a season.

You're also quite well known for being able to pick out good pubs. How did this come about?

I had a love of reading about London, going to pubs and I didn't mind the odd beer so I combined these and had a website for which I made pub crawls for different areas of London. I just liked the idea of this and it was a good way of learning about areas, pubs and beer! For example, if I said to a group of ten people tomorrow, "let's go on a pub crawl" , they wouldn't go, but if you make a map, linking it with quotations and history of the area then it appeals more. The first one I did was around 1993. Walking from Charing Cross to GOSH and back via Cannon Street each day for 35 years inevitably makes you think, "oh I'll check that one out one day". We all used to go out quite a lot after work in the early days and I would often suggest which pubs to go to and they gradually became more popular, for some reason!

You've recently gone down to two days a week at work and are starting to wind down a bit. What does the future hold for Aidan Laverty?

Well, I'm doing some voluntary gardening at Greenwich park, for a few hours per week. One reason for starting this was in order to be of any help to my wife, Joan, who is a keen gardener and I have little knowledge. I have returned to playing table tennis, which I last played in the 1980s. Also of course, extra time is good for catching up with reading and music. I'd like to stay as I am at work for the foreseeable future and we've done some good succession planning at GOSH.

I have some quick fire questions for you now Aidan so just tell me what comes to your mind first.

QUICK FIRE QUESTIONS

Favourite food & drink?
Thai and London Pride

Celebrity crush?
You know I don't believe in objectification. I prefer intelligence!

Favourite film?
Not really a film person, though I recently rewatched "The Blues Brothers" after many years and I think it still holds up

Favourite band?
I have been to Glastonbury many times and enjoyed the TV coverage recently - LCD Soundsystem and PJ Harvey were my favourites.

Favourite pastime?
Reading and music. Too many authors to mention - W.G. Sebald, Kazuo Ishiguro. I tend to go to music gigs in small venues nowadays rather than massive venues. I also enjoy the theatre and have been to this a lot since I cut my work days. Another hobby is walking with a destination pub at the end!

Nicknames you've had?
Lozza

Karaoke song?
"Bet you look good on the dance floor" and "Superstition" which I once sang whilst out with the GOSH netball team!

Favourite holiday destination?
Back in the days, Joan and I visited Thailand, Malaysia and Bali and we found Bali the most relaxing. We also like to visit Scotland and would like to go back to Orkney one day.

Favourite memory?
My wedding day and the birth of my children, of course! Sunny holidays on the Isle of Wight with Joan and the kids and a sunny day at Glastonbury when you're setting up your tent and you know you have five days of hedonism ahead of you. .

Biggest bugbear?
If we keep politics out of this, I'd say that big money tends to ruin things. Good examples would be professional football and concert ticket prices!

FRESH AIR

Edited by **Dr James Stockley** *ARTP Chair of Research and Innovation*

Dear Reader,

Welcome back to 'Fresh Air'. These articles are designed to communicate novel trends in research, innovation and clinical practice from both respiratory and sleep sciences. Our aim is to provoke thought and conversation within the ARTP community that we hope will benefit the future direction of physiological practice.

For this issue, Natalie Orr and Charlotte Richardson have provided an article on the use of CPET in diagnosing breathing pattern disorder and dysfunctional breathing. Natalie and Charlotte are both physiologists at the Royal Brompton's Paediatric CPET service, working with children and young people who have respiratory conditions including asthma, long COVID, and breathing pattern disorder. Natalie presented this work at the 2023 ARTP Conference and was awarded the Dame Sue Hill award for the best oral presentation.

Cardiopulmonary exercise test to identify breathing pattern disorders in children with exertional dyspnoea

Introduction

The terms breathing pattern disorder (BPD) and dysfunctional breathing (DB) are collective umbrella terms that are used to describe deviations from the natural biomechanical patterns of breathing[1]. Altered breathing patterns can affect children and adults and are typically associated with dyspnoea and symptoms that may be acute or chronic in nature. These deviations from typical breathing patterns can exist in the presence or absence of organic disease[2]. BPD may have multiple causes or exacerbation factors, and the cause of initial onset can vary from the factors that perpetuate it[3]. Once a pattern of DB has been established, it may become habitual, and thus difficult to differentiate from symptoms of organic origin and challenging for the individual to overcome without intervention.

BPD encompasses various types of breathing dysfunction, with hyperventilation syndrome being one of the most common forms reported in literature[4]. BPD can range in severity and can affect anyone, although it is relatively common in the athletic population. BPD can have a profound effect on both physical and psychological health. Untreated BPD can not only lead to exercise avoidance, but also decreased school attendance, increased hospital presentations, and the escalation of medications which may not be appropriate or beneficial. These consequences of BPD can significantly impact the quality of life of a child or young person and result in higher economic cost to healthcare providers[5].

Correctly diagnosing BPD, particularly in subjects presenting with exercise induced dyspnoea, can be a challenging task for healthcare professionals. A useful diagnostic tool for exercise-induced dyspnoea caused by BPD is cardiopulmonary exercise testing (CPET). This assesses an individual's ventilatory, cardiac, gas exchange, and metabolic responses to exercise and provides valuable information into the pathophysiological cause of exercise-induced dyspnoea that cannot be obtained at rest[1]. In some circumstances, once a diagnosis of BPD has been confirmed, individuals may experience a decrease in their symptoms as it can provide reassurance to them[4]. In most cases, however,

some form of treatment is required. There is no agreed standard treatment, but a widely recognised treatment approach to BPD is physiotherapy intervention. Physiotherapy has been shown to improve quality of life and can produce significant improvements in physical health in children and young people with this problematic condition[6].

Patients are referred to our paediatric CPET service for many reasons, but the most common reason is for the evaluation of "shortness of breath on exertion". The objective of our study was to ascertain the prevalence and pattern of BPDs in our paediatric cohort. There is an established clinical pathway for patients that present with characteristics of BPD and current practice is to refer for a CPET to confirm the presence of BPD and/or elucidate other pathology. Thereafter, if BPD is confirmed as their primary problem, individuals are referred to a specialist respiratory physiotherapist for a blended approach of face-to-face and online education intervention.

Methods

We retrospectively analysed CPET data since inception of our paediatric CPET service in June 2022. To better distinguish the relationship between breathing frequency and tidal volume, we use the graph as displayed in the figures below. BPD was identified on visual assessment and the consensus of an expert multidisciplinary team (experienced physiologist, specialist physiotherapist, and consultant lead).

Results

Data from 40 patients was analysed, (18 male; median age 13yrs, range 9-16yrs), (22 female; median age 14yrs, range 8-17). 32 (80%) were noted to have BPD and were referred for specialist respiratory physiotherapy for assessment and breathing retraining. The outcomes for the remaining eight patients were varied, but included exercise-induced bronchoconstriction, physical deconditioning, and symptom monitoring. Of the 32 patients that presented with BPD, three predominant altered breathing patterns were identified and are discussed below. Prior to discussing the case

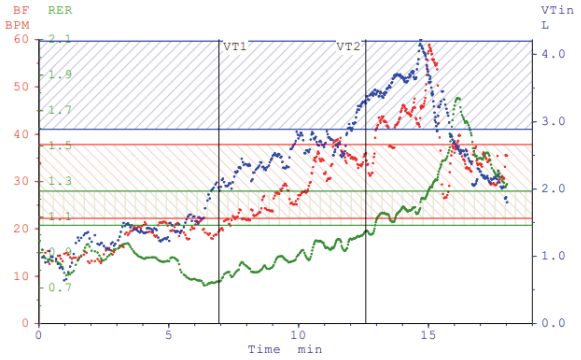


Figure 1. A normal physiological response to exercise, as demonstrated by plotting breathing frequency (BF) in red, tidal volume (VT) in blue and respiratory exchange ratio (RER) in green against time.

studies of altered or dysfunctional breathing, it is important to highlight what a normal response to exercise looks like with a graph that we use in addition to the traditional CPET nine-panel plot. This new graph plots tidal volume (VT) and breathing frequency (BF) against time to further help us distinguish a patient's breathing pattern response during exercise. As seen in this example from a healthy subject (Fig 1), there is a steady increase in tidal volume and breathing frequency throughout exercise.

The first case study of a patient with BPD is a 10-year-old male referred for a CPET due to shortness of breath on exertion who was also experiencing symptoms of dizziness and a tingling sensation in fingers with exercise. This patient demonstrated very good aerobic fitness during the CPET.

The relationship between VT and BF over time (Fig 2) highlights the breathing pattern abnormalities in this patient. The graph shows that BF and VT are highly erratic from the onset of exercise and, despite the increase being linear, the relationship is not synchronised. The outcome for this patient was that they were referred for a breathing pattern assessment with a specialist physiotherapist to work on techniques to optimise breathing pattern during exercise. It is important to emphasise that even patients with excellent aerobic fitness can still experience breathing pattern disorders and, as

FRESH AIR

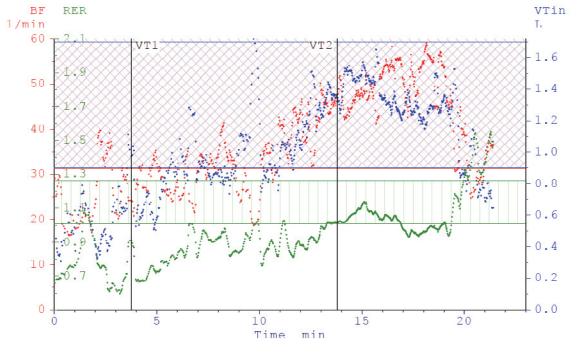


Figure 2: Breathing frequency (BF) in red and tidal volume (VT) in blue against time for a 10-year-old male with highly erratic breathing from the onset of exercise.

previously mentioned, it is increasingly prevalent in athletes.

The next interesting case study was a 10-year-old female with asthma, referred for shortness of breath on exertion. As demonstrated on the BF and VT graph (Fig 3), there is an erratic BF throughout exercise and, of particular importance, a stunted tidal volume response. This is a good example of a patient that is not engaging their diaphragm during exercise instead typically utilising their accessory muscles and/or apically breathing to increase ventilation. The outcome for this patient was a breathing pattern assessment and breathing retraining, with particular emphasis on correct engagement of the diaphragm. While the incidence of asthma

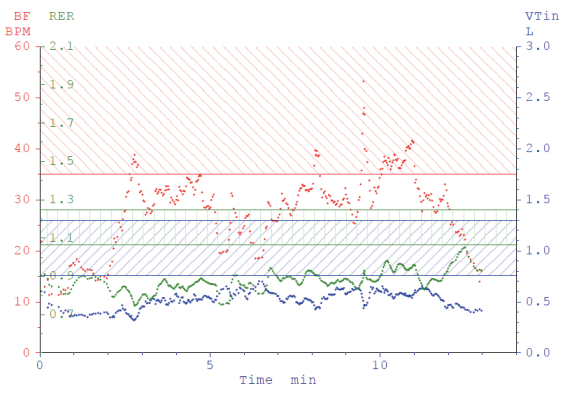


Figure 3: Breathing frequency (BF) in red and tidal volume (VT) in blue against time for an 11-year-old female with asthma. The plot shows highly erratic breathing throughout exercise with a stunted tidal volume response, indicating poor diaphragmatic engagement.

and BPD remain unknown, it is common to see BPD in this cohort.

This final case study is a 16-year-old male also with a confirmed diagnosis of asthma. He was referred for shortness of breath on exertion and a high reported symptom burden, despite high-dose inhaled corticosteroid treatment. This patient did demonstrate some elements of physical deconditioning during their CPET. In this case, the plot shows the patient is taking extremely large tidal volumes, often exceeding physiological norms, in response to exercise (Fig 4). The lack of compensatory hyperventilation (low BF) may be perpetuating symptoms of secondary exercise induced laryngeal obstruction in this patient. Following the CPET, he was referred to a specialist respiratory physiotherapist for an assessment and breathing retraining, with emphasis on increasing BF appropriately.

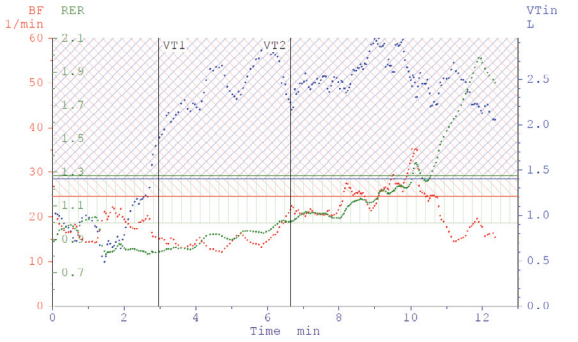


Figure 4: Breathing frequency (BF) in red and tidal volume (VT) in blue against time for a 16-year-old male with asthma. The plot shows a rapid increase in tidal volume with an attenuated breathing frequency response (no compensatory hyperventilation).

When the graphs are displayed together (Fig 5), it is interesting to observe the three altered breathing patterns and the differences in the relationship between BF and TV. All three abnormal plots demonstrate a breathing pattern disorder, although the abnormalities identified in each are distinct. Even in the realms of breathing pattern disorders, we can see huge variation in the relationship between BF and VT. These sub-optimal breathing patterns may be significantly

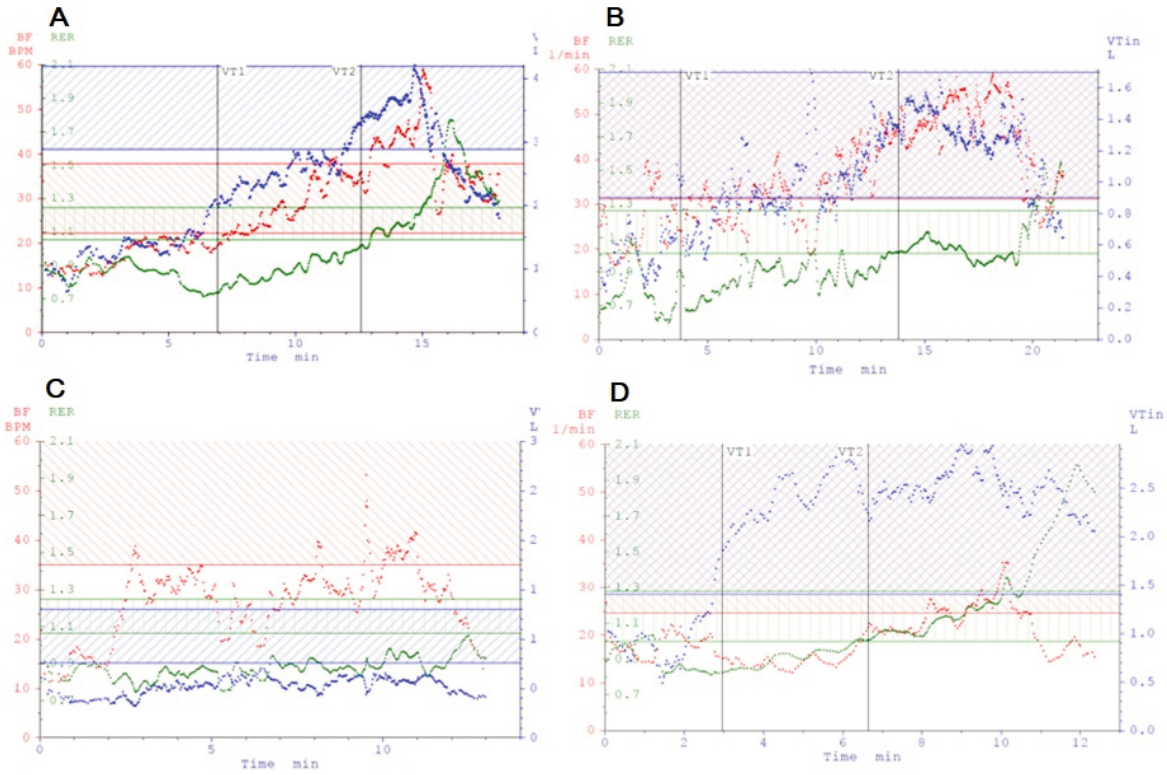


Figure 5: Examples of breathing pattern response to exercise shown together: **A**. Normal, **B**. Erratic breathing frequency (red) and tidal volume (blue) throughout exercise, **C**. Stunted tidal volume with erratic breathing frequency, **D**. Large tidal volumes with no compensatory hyperventilation.

impacting exercise performance. The novel BF/VT versus time plot emphasises the importance of identifying the type of breathing pattern disorder that the patient is presenting with in order to establish targeted treatment pathways and appropriate physiotherapy intervention.

Discussion

A significant finding from our service review was the high prevalence of BPD (80%) in the children and young people referred for CPET for exertional dyspnoea. The additional graph of tidal volume and breathing frequency against time helps identify altered breathing patterns. BPD in children and adolescents requires ongoing research to ascertain prevalence and to establish correct treatment pathways. The impact that BPD can have on an individual should not be underestimated. Undiagnosed or untreated BPD can be costly to healthcare providers and can lead to exercise avoidance, which may perpetuate other conditions. The magnitude of the disorder and the implications it holds should be of the utmost importance to health and fitness professionals as the correct treatment may significantly improve an individual's athletic ability and performance and, crucially, their overall quality of life.

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Lab in the Limelight

Lisa McManus
Chief Respiratory Physiologist,
Respiratory Investigations Unit

South West Acute Hospital, Enniskillen, Co. Fermanagh, Northern Ireland.

History & Overview of the Department

The South West Acute Hospital (SWAH) is built on the shores of Lough Erne. It is one of three primary hospital sites covering the Western Health and Social Care Trust (WHSCT), an area of 4,842km^2 (predominantly rural) with approximately 12,000 staff.

The Trust opened its doors to patients at 8am on 21 June 2012. Patients were transferred from the Erne Hospital as it closed to all future admissions. The hospital has up to 210 inpatient beds (all wards are single room occupancy) and 22 day care beds.

As well as a wide range of acute and community-led services, included on site is: staff accommodation, an education centre, lecture theatre, key worker accommodation, an energy centre and a crèche.

Our respiratory team provides services for a full range of respiratory diseases, with a Multi-Disciplinary Team consisting of: consultant doctors and their medical teams, specialist nursing teams, physiologists, physiotherapy staff and other allied health professionals including a community respiratory team.

Lab in the Limelight continued

The service has eight Chest Clinic sessions per week, bronchoscopy lists and was the first hospital in Northern Ireland to offer Linear Endobronchial Ultrasound (EBUS) in 2012 followed by Radical EBUS in 2014. This method enables early diagnosis of cancer and enables the clinician to determine the exact location and size of the lesion.

This year saw the introduction of the Rods & Cones technology which provides first class medical education to our medical students. This is the first time these have been used in Europe. Smart glasses are worn by the surgeon in theatre offering a live view of the surgical field to students located in the education centre.

A Cardio-Respiratory Investigations Lab was included in the design and build of the new site with some equipment procured. However, the Respiratory & Sleep Lab section of the department was initially a satellite clinic, with visiting respiratory physiologists attending 1-2 times monthly from Altnagelvin Area Hospital which was 52 miles away. In June 2013, the first permanent member of staff (myself) was employed to manage and oversee the day to day running of both the South West Acute Hospital (four days per week), also covering Omagh Hospital (30 miles away) on a visiting basis one day per week. The service then became known as the Respiratory Investigations unit (RIU).

I was initially employed as a Band 6 which was uplifted to a band 7 as the service was developed to accommodate the population within the Southern Sector of the trust. Over the past 11 years these services have continued to flourish and grow. We now provide a full range of full pulmonary function tests including: helium dilution, nitrogen washout, supine VC, mouth pressures, SNIP, reversibility studies, FeNO, bronchial challenge testing (mannitol), six-minute walk testing, cardiopulmonary exercise testing, overnight oximetry and multi-channel sleep studies. Over time I have been able to use my skills from my previous job to introduce: body plethysmography, skin prick allergy testing, capillary blood gas analysis, hypoxic challenge testing and transcutaneous CO2 monitoring.

The RIU provides services to a wide range of multi-disciplinary teams including: Cardiology, Neurology, Oncology, Stroke, Nephrology, Pre-op assessment, General medicine, Care of the Elderly, and Rheumatology. Our non-respiratory referrals are approximately 40% of our total referrals.

Lead Physiologist background and career

My name is Lisa and with over 20 years' experience in the field, I joined WHSCT in June 2013. Having trained in the Royal Victoria Hospital Belfast in 2003, I secured my first NHS role in the Regional Respiratory Centre at Belfast City Hospital as a Trainee MTO in January 2004 (some of you will be old enough to remember what that was!). I continued my BSc (Hons) in Clinical Physiology in the University of Ulster, Jordanstown whilst working full time until graduating in 2005, at which point I was awarded an MTO 1 (equivalent to a Band 5 position). After one year I secured a MTO 3 (Band 6) in November 2006, remaining in this position until June 2013.

Throughout my time in Belfast City Hospital I was privileged to work with a large number of amazing consultants and physiologists, with Dr Brian Buick (Clinical Scientist) as my manager and mentor. Brian was always forward thinking, championing education. It was his guidance that led me to the City of Westminster College to undertake my ARTP Parts 1 and 2 (obtaining Merits in both).

I relocated to South West Acute Hospital, as not only was this an amazing opportunity to develop a new service, but it was also in my home county and therefore a role I knew I would likely remain in for the remainder of my career. A new department, in a high spec facility within 'Ireland's Lake District' – what more could anyone ask for?

Eleven years later and though I still miss my colleagues in Belfast, I can honestly say it was the best decision I could have made. The team we have developed continues to grow, as do the services we provide. We are a teaching hospital, heavily involved in undergraduate education. I am immensely proud of the students we have mentored and the high standard of qualifications they have achieved. I have guest lectured on the current Healthcare Science degree at University of Ulster since 2017 and continue to encourage each student to undertake ARTP examinations.

Lab in the Limelight continued

The Team

Left to right. Gavin, Samantha, Lisa, Deborah, Peter

Unfortunately, a number of factors including the dissolution of the Northern Irish assembly and financial constraints have limited our ability to secure additional permanent physiology staff; however our team has grown. The RIU has 0.26 WTE secretarial support (Deborah), 0.20 ATO (Gavin) and two WTE Band 6 long term locum physiologists (Samantha and Peter). In terms of medical staff, we have one permanent respiratory clinical lead, three long term respiratory locum consultants, one Respiratory Staff Grade, two Clinical Fellows and an SHO. We also have a visiting ILD specialist consultant bi-monthly and ILD nurse specialist. In terms of nursing support, we have one clinical nurse specialist (respiratory and cancer), one respiratory nurse specialist and one part time respiratory nurse specialist for CPAP therapy, along with a community respiratory team of approximately ten nurses.

Achievements & Innovation

We started 2024 on a high note! In order to cope with increased service demands we have restructured our physiology outpatient services, including the introduction of protected days for red flag patients. These changes have streamlined services, with a recent audit observing an additional 63 tests per physiologist per month, without compromising patient care; on the contrary, each day is more structured, organised and manageable.

Lisa receiving her "Gerry McKenna healthcare science" award from Prof McKenna

I was recently nominated by my clinical lead for Western Health and Social Care Trust's Inaugural Annual Professor Gerry McKenna Award for staff excellence in medical science. This award was open to all staff working within scientific and technical roles, recognising individuals who have shown a passion for healthcare sciences, who champion and deliver developments in the contribution of science to health focusing on patient focused care, strive to promote healthcare science careers or proactively drive implementations of modern science and technology to improve the lives of patients. I was privileged to be announced winner in April.

I have recently been informed the trust would like to put me forward for the Advancing Healthcare Awards Northern Ireland 2024 – another amazing opportunity.

Future directions/developments for the lab

Next on the 'to do list' - to bite the bullet and complete STP equivalence! I want to continue to work with our team and line manager to develop the services we offer. Securing funding for permanent physiology and support staff Trust-wide is essential and will enable us not only to improve on the services already delivered but to also become more involved with the Respiratory Nurse Specialists in the delivery of CPAP therapy (something we as a team miss a lot!). Lastly, but just as important is to continue to engage and develop our Northern Ireland respiratory and sleep communities where we strive to ensure standardised services across all five Trusts so that we can deliver the best possible care to patients.

Errors in the guidelines for spirometric assessment of bronchodilator therapy in emphysema

DCS Hutchison (Retired) *Ex. Senior Lecturer (1968-1996), Department of Respiratory Medicine, King's College Hospital and Medical School, London SE5*

SUMMARY

The FVC has long been known to underestimate the true VC in patients with emphysema.

Present and past guidelines for the assessment of bronchodilator response in this disorder continue to recommend use of the FEV_1 or FEV_1/FVC ratio for this purpose. The scientific evidence shows that a relaxed form of the VC provides a more reliable assessment of bronchodilator response in such patients.

ABBREVIATIONS

FEV_1 – Forced expiratory volume in one second
VC – Vital Capacity
FVC – Forced expiratory VC
IVC – Relaxed inspiratory VC
EVC – Relaxed expiratory VC
BTS – British Thoracic Society
ARTP – Association for Respiratory Technology and Physiology

Introduction

Many patients with emphysema report relief of shortness of breath following inhalation of a bronchodilator drug, though the commonly used tests of airflow obstruction such as the FEV_1 or FEV_1/FVC ratio may remain unchanged. Gilson and Hugh-Jones[1] pointed out, over 70 years ago, that in such patients, a very rapid expiration may give a figure for the VC which is too low. It was later confirmed[2] that the FVC is significantly smaller and more variable than the IVC or EVC in such patients. A significant proportion (19%) of similar patients referred for bronchodilator assessment had an increase in VC without any increase in expiratory flow indices[3] and these authors firmly recommended that changes in static lung volumes should be utilised as an index of bronchodilator responsiveness. Further studies[4,5] showed that an increase in the vital capacity after bronchodilator (sometimes by as much as one litre) was more consistently related to symptomatic improvement and was usually accompanied by a corresponding reduction in residual volume.

Examination of inspiratory and expiratory flow-volume curves in emphysema provided further evidence of the mechanisms involved.[6] One must note that FV curves may not be performed in all laboratories, but the slow or relaxed expired VC can be regarded as equivalent to the IVC.

The problem

The problem in part arises from the practice of grouping patients with a persistently low FEV_1 under a common heading such as chronic obstructive bronchitis or COPD.[7] Patients with emphysema may, quite naturally, fall into such groups. This practice ignores the fact that a reduction in FEV_1 can arise from two fundamentally different mechanisms, the physiological principles of which were described in detail by NB Pride some years ago.[8]

Mechanism 1

The first mechanism is simply a narrowing of the small airways as in asthma or chronic obstructive bronchitis.

Mechanism 2

The second and quite different mechanism arises in generalised emphysema, where destruction of the elastic tissue results in an increase in lung compliance and a reduction in support for the intrathoracic airways. During a forced expiratory manoeuvre therefore, the high intrathoracic pressure which is generated may in severe cases result in virtual closure of these airways. Under such conditions the administration of a bronchodilator would not be expected to alter the results of tests like the FEV_1 unless, for instance, an asthmatic element was also present. This matter is discussed in detail in an early paper on this subject,[4] where it was clearly shown that in emphysema the slow or relaxed VC is a much more reliable indicator of bronchodilator responsiveness than the FEV_1.

Some published guidelines

Several workers in the field have published guidelines which include the spirometric assessment of bronchodilator response in emphysema and four examples of such guidelines are reviewed below.

- BTS/ARTP Liaison Committee (1994)[9]

  These guidelines state that the FEV_1/VC ratio should be calculated using the greatest FEV_1 obtained and expressing it as a percentage of the greatest VC – whether the VC is from a forced or a relaxed manoeuvre. The common practice of

only reporting the FEV_1/FVC can be misleading as FVC may frequently underestimate the true VC2.

Maximal Flow Volume Curves: These guidelines also illustrate a typical curve from an emphysematous patient. The curve clearly demonstrates the collapse of large airways, resulting in a sudden drop in flow early in the expiratory part of the manoeuvre. The inspiratory limb is unaffected since the airways are being kept open by transmural pressure. The appearance is obviously quite different from that usually seen in an uncomplicated asthmatic patient.

- **BTS Guidelines 1997[10]**

  These guidelines also contain a section on reversibility testing to bronchodilators. The discussion however refers only to use of the FEV_1 and the authors go no further than to note that a negative FEV_1 response does not preclude benefit in terms of walking distance or a sense of dyspnoea. This was a small section in a more generalised review (28 pages) with a wider group of committee members, very few of whom were on the 1994 committee. A little surprisingly, there is no reference to the joint BTS /ARTP Guidelines of only three years earlier.[9]

- **ARTP statement on pulmonary function testing 2020[11]**

  In these relatively recent guidelines, in the main section on bronchodilator response, six methods of calculation are discussed, all based on FEV_1 without including any version of the VC. The authors do however note separately that improvement in FVC post bronchodilator was greater in the more severe cases, suggesting some relief of hyperinflation.

- **Global Initiative for Chronic Obstructive Lung Disease. 2023 Report[12]**

  This publication (known for short as the 'GOLD report') is the most recent of the annual reports produced by the representatives of some 40 countries. In the section on spirometry, the report recommends that the bronchodilator response should be measured using the FEV_1 and FEV_1/FVC. The authors' further remark that even with a normal FEV_1/FVC ratio, COPD can be present. Measurements during inspiration such as the IVC are not mentioned.

Conclusion

It is clear from many of the early studies that the FVC is not a suitable method for the measurement of VC in patients with emphysema, but it is far from clear why this principle has been generally ignored in Guidelines published from the year 1997 onwards. The relaxed VC is clearly the most reliable indicator of bronchodilator response in such patients and is best performed as a slow unforced inspiratory manoeuvre. This response is still not well recognised and reliance on forced expiratory manoeuvres alone may mean that many bronchodilator-responsive patients are denied a clinically effective line of treatment.

Acknowledgements

The author owes grateful thanks to the many patients, physiologists and clinicians who contributed to our past joint research and to Celia Hutchison who assisted with the submission process.

Author interests

The author was chair of the BTS/ARTP Liaison Committee which drew up the 1994 Guidelines.

Financial interest: None

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ON THE BLOWER

Vyaire Medical: A History of Thinking Forward

Customers will have received news that Vyaire Medical have voluntarily filed for chapter 11 protection in the United States. Chapter 11 is a form of bankruptcy that allows a company to stay in business and restructure its finances and operations.

Vyaire Medical consists of respiratory diagnostics and ventilation sections of the business. They struggled to finance their debt after a below-plan performance in the first half of the financial year.

What does this mean for customers? Initially, Vyaire in the UK have said it will be business as usual and customers will not be affected in the short term. Long term though, the company will need to find a suitable buyer and this may mean another name change which will not be new to historical customers. Watch this space.

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ARTP Annual Conference – A big thank you!

We would like to thank the ARTP for putting on another great conference, and the ARTP members for coming to our stand and recognising the efforts we put in, with voting for Vitalograph as having the best stand! We could have filled a stand space twice the size with all our products and solutions, so it was great to be able to talk with delegates about what we can offer.

We brought in Professor Carl Mottram, former Technical Director of the Mayo Clinic PFT Laboratory and Associate Professor of Medicine, for a workshop on the ERS/ATS Technical Standard Lung Volumes 2023 Update, as one of the authors. Another workshop was delivered by Gareth Morgan from Morgan Scientific Inc. to speak in detail about future plans for our ComPAS2 PFT application software.

Focusing on you and your patients

The conference presented the perfect opportunity for us to talk to our customers about our definition of PFT as **Patient Focus Time**. We recognise the passion and drive of healthcare professionals to do the best for their patients and we want the experience of working with Vitalograph and our solutions to represent this.

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We are delighted to welcome Shaun and Tanya to Vitalograph UK Respiratory Diagnostic Solutions team.

Shaun Beck, *Secondary Care Territory Manager – North*
Email: Shaun.beck@vitalograph.co.uk
Direct phone: 07725 421539

Tanya Rose, *Business Development Manager – Primary Care and Occupational Health*
Email: Tanya.rose@vitalograph.co.uk
Direct phone: 07521 625205

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Dr Joanna Shakespeare[1]
[1]UHCW NHS Trust, Coventry, Coventry, United Kingdom

O2 Quality Assurance in a Respiratory Laboratory: How compliant are you?
Mr Calvin Apen[1], Mr Muhammad Ifraan Khan[1]
[1]York & Scarborough Nhs Foundation Trust, Doncaster , United Kingdom

O4 Could the 6-Minute-Walk-Test be shortened in duration and still capture significant oxygen desaturations in patients with interstitial lung disease?
Miss Lucy Robertson[1]
[1]Royal Papworth Hospital, Cambridge, United Kingdom

P2 The Assessment of Respiratory Entropy in Chronic Obstructive Pulmonary Disease Using Structured Light Plethysmography
Miss Megan Walton[1], Dr James Stockley[1], Mr Eyas Alhuthail[1], Dr Andrew Coney[1], Prof Brendan Cooper[1]
[1]University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK, [2]University of Birmingham, Birmingham, United Kingdom

P4 Oscillometry in routine lung function testing: A UK-based survey
Miss Madison Geeves[1], Dr Harry Griffin[1], Dr Michael Hughes[1], Dr Karl Sylvester[2], Dr Lindsay Welch[3], Dr Zoe Saynor[4]
[1]Hampshire Hospitals NHS Foundation Trust, , England , [2]Royal Papworth Hospital NHS Foundation Trust, Cambridge, England, [3]Bournemouth University and University Hospitals Dorset NHS Foundation Trust, Bournemouth, England, [4]University of Portsmouth, Portsmouth, England

P5 It's not all about Asthma! The prevalence of alternative diagnosis in patients with confirmed or suspected asthma.
Mrs Megan Robshaw[1], Mrs Emma Raywood1, Mrs Helen Parrott[1]
[1]NuvoAir Clinical Service, United Kingdom

P8 Comparison of dead space estimates using Fowler and Cotes sampling methods during gas transfer.
Miss Lucy Robertson, Dr Karl Sylvester
[1]Royal Papworth Hospital, Cambridge, United Kingdom

P9 The suitability of obtaining a single acceptable gas transfer result.
Mr Joshua Barnes[1], Miss Heather Nuttall[1], Mr Andrew Collingwood[2], Dr Karl Sylvester[1,3]
[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, UK, [2]Counties Manukau, Te Whatu Ora, Auckland, New Zealand, [3]Cambridge University Hospitals, Cambridge, United Kingdom

P10 Retrospective audit analysing the effects of applying the Global Lung Initiative (2021) reference ranges on static volumes for non-Caucasian population
Ms Manisha Perera[1], Ms Lauren Kimberley[1], Mr Mark Unstead, Dr Adrian Kendrick[2]
[1]Royal Berkshire Hospital, Reading, United Kingdom, [2]University of West of England, Bristol, United Kingdom

P12 Exploring physiological discordance between spirometry and gas transfer in idiopathic pulmonary fibrosis (IPF)
Miss Absari Choudhury[1], Dr Joanna Shakespeare[1], Prof David Parr[1]
[1]University Hospital Coventry & Warwickshire, Coventry, United Kingdom

P13 Evaluation of pre-bronchodilator FEV1/VCMax z-score in the context of significant bronchodilator response in patients with an FEV1/VCMax z > -1.645
Mr Dominic Evans[1], Mr Muhammad Irfaan Khan
[1]York Teaching Hospital NHS Trust, York, United Kingdom

P14 Is the Forced Oscillation Technique a suitable surrogate for more volitional lung function testing in COPD?
Miss Ella O'Neill[1], Dr Ben Knox-Brown[2], Dr Karl P Sylvester[1,2]
[1]Cambridge University Hospitals, Cambridge, United Kingdom, [2]Royal Papworth Hospital, Cambridge, United Kingdom

P15 A retrospective review of home-based spirometry quality in an adult lung transplant cohort.
Mr Bryn Williams[1], Miss Rebecca Borton[2], Dr Caroline Patterson[1], Dr Karl Sylvester[1,3]
[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]patientMpower, [3]Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

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P16 Home-based spirometry: is one effort enough?
Mr Bryn Williams[1], Miss Rebecca Borton[2], Dr Caroline Patterson[1], Dr Karl Sylvester[1,3]
[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]patientMpower, [3]Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

P17 A case study on the effect of keeping an African Grey Parrot: Hypersensitivity Pneumonitis.
Miss Ella O'Neill[1], Mr Christopher J Harding[1], Dr Karl P Sylvester[1,2]
[1]Cambridge University Hospital, Cambridge, United Kingdom, [2]Royal Papworth Hospital, Cambridge, United Kingdom

P22 A Quality Assurance Review Model for Pulmonary Function – The Royal Papworth Method.
Miss Holly Le Winton[1], Miss Lucy Robertson, Mr Joshua Barnes, Mr Karl Sylvester
[1]Royal Papworth Hospital, Cambridge, United Kingdom

P25 UHNM Respiratory Physiology service improvement initiative: A review of the departmental new clinic structure; how has this benefited the department/service?
Mrs Elizabeth Powell[1], Ms Rachel Heath[1]
[1]University Hospitals Of North Midlands, Stoke-on-Trent, United Kingdom

P27 Occupational asthma due to mild steel?
Mr Samuel Wallbanks[1,3], Dr Kimberley Nettleton[1,3], Mr Christopher Huntley[1,3], Dr Vicky Moore[2,3], Professor Sherwood Burge[3], Mr Gareth Walters[1,3]
[1]Birmingham Heartlands Hospital, Birmingham, United Kingdom, [2]University Hospitals Coventry & Warwickshire, Coventry, United Kingdom, [3]Birmingham Occupational Lung Service, Birmingham, United Kingdom

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Mrs Sara Mcarthur[1], Mr Shaun Baxter[1]
[1]The Royal Infirmary of Edinburgh, NHS Lothian, Edinburgh, Scotland

P32 Noisy Breathing during exercise in a Cystic Fibrosis patient - What's the cause?
Colleen Carden[1], Paul Burns, Ross Langley, Philip Davies, David Wynne
[1]Royal Hospital for Children, Govan Road, Glasgow, United Kingdom

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Dr Ben Knox-Brown[1], Mr Chris Harding[2], Dr Karl Sylvester[1]
[1]Respiratory Physiology, Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]Respiratory Physiology, Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

P34 Is the oxygen uptake efficiency slope (OUES) a good surrogate for VO2 peak in patients with unexplained breathlessness?
Mr Chris Harding[1], Dr Chara Alexiou[1], Dr Ben Knox-Brown[2], Dr Karl Sylvester[1,2]
[1]Cambridge University Hospitals NHS Trust, Cambridge, United Kingdom, [2]Royal Papworth Hospital NHS Trust, Cambridge, United Kingdom

P35 Evaluation of a physiologist-led paediatric home spirometry assessment
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[1]Nuvoair Clinical Team, United Kingdom

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Miss Natalie Blyth[1], Mr Joe Madge[1], Ms Gemma Vissani[1], Ms Charlotte Simpson[1], Mr Prakash Patel[1], Dr Vinyak Rai[1], Dr David Lo[2], Dr Molla Imaduddin Ahmed[1], Dr Erol Gaillard[2]
1University Hospitals Of Leicester, Leicester, United Kingdom, 2University of Leicester, Leicester, United Kingdom

P37 Post COVID Persistent Exercise Induced Dyspnoea in Children and Young People: Is CPET the key test?
Miss Charlotte Richardson[1], Miss Natalie Orr[1], Dr Ioannis Makariou[1], Dr Terry Y Segal[2], Dr Samatha Sonnappa[1]
[1]Royal Brompton Hospital, London, United Kingdom, [2]University College Hospital (UCH), London, United Kingdom

P38 Determining the inter-rater agreement of the VO2 at AT between CPET practitioners within a large tertiary CPET service
Mr Jason Burge[1]
[1]University Hospital Coventry and Warwickshire NHS Trust (UHCW), CV22DX, United Kingdom

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Colleen Carden[1], Paul Burns, Rebecca Lennon, Ross Langley, Philip Davies

[1]Royal Hospital For Children, Govan Road, Glasgow, United Kingdom

P40 A simple method for checking that lung function test results are quality assured correctly and consistently between respiratory physiologists

Dr Harpal Kalsi[1], Ms Janina Mallari[2], Dr Hajar Hajmohammadi[1], Dr James Scales[1], Dr Ivelina Tsocheva[3], Ms Jasmine Chavda[3], Dr Rosamund Dove[1], Dr Helen Wood[1], Dr Ian Mudway[4], Ms Grainne Colligan[1], Mr Luke Sartori[1], Mr Jason Le[1], Ms Jessica Mitchell[1], Ms Jessica Moon[1], Professor Gurch Randhawa[3], Professor Chris Griffiths[1]

[1]Queen Mary University of London, London, United Kingdom, [2]Barts Health NHS Trust, London, United Kingdom, [3]University of Bedfordshire, Luton, United Kingdom, [4]Imperial College London, London, United Kingdom

P41 The risks of applying normative values in paediatric cardiopulmonary exercise testing: a case report

Mrs Jessica Waterfall[1], Mrs Dawn Shackell[2], Dr Joanna Pepke-Zaba[3], Mrs Katrina Oates[1], Dr Karl Sylvester[4]

[1]Respiratory Physiology Department, Royal Papworth Hospital NHSFT, Cambridge, United Kingdom, [2]Respiratory Physiology Department, Norfolk & Norwich University Hospital NHSFT, Norwich, United Kingdom, [3]Pulmonary Vascular Disease Unit, Royal Papworth Hospital NHSFT, Cambridge, United Kingdom, [4]Lung Function Unit, Cambridge University Hospitals NHSFT, Cambridge, United Kingdom

P42 Respiratory Physiologist's Role in reducing the risk of acute deterioration in Paediatric Patients

Daniel Woodcock[1], DR Meredith Robertson

[1]Evelina London Children's Hospital, Guy's & St Thomas' NHS Foundation Trust, London, United Kingdom

P43 Rectal ointment for your aCBG appointment: gunpowder, good reason, no clot

Dr Harry Griffin[1], Dr Lee Dexter[2], Dr Michael Hughes[1], Miss Madison Geeves[1]

[1]Respiratory Physiology and Sleep Department, Hampshire Hospitals NHS Foundation Trust, UK, Basingstoke, United Kingdom, [2]Respiratory Medicine Department, Hampshire Hospitals NHS Foundation Trust, UK, Basingstoke, United Kingdom

P44 An unusual physiological response to exercise in an adult Fontan patient – A case study

Mr Joshua Barnes[1], Miss Kate Donovan[1], Dr Victoria Stoll[1], Dr Karl Sylvester[1,2]

[1]Royal Papworth Hospital NHS Foundation Trust, [2]Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

P45 The role of cardiopulmonary exercise tests in a Leicestershire paediatric respiratory cohort.

Mr Joe Madge[1], Natalie Blyth[1], Dr Molla Imaddudin Ahmed

1University Hospitals of Leicester Trust, Leicester, United Kingdom

P46 Using RER values as a retrospective marker of maximal exertion during cardiopulmonary exercise tests: Findings of a single database review

Miss Isobel Briggs[1], Mr Josh Barnes[2], Mr Max Thomas[3], Dr Mark Faghy[4], Dr Karl Sylvester[5]

[1]Doncaster Royal Infirmary, Thorne Road, , United Kingdom, [2]Royal Papworth Hospital, Papworth Road, Trumpington, United Kingdom, [3]Birmingham Heartlands Hospital, University Hospitals Birmingham, United Kingdom, [4]Biomedical and Clinical Exercise Research Theme, University of Derby, United Kingdom, [5]Cambridge University Hospitals, NHS Foundation Trust, Cambridge, UK and Royal Papworth Hospital NHS Foundation Trust, Cambridge, UK

P47 Accuracy of automated BP machines during maximal exercise testing

Mr Daniel Grant[1]

[1]Leeds NHS, Leeds, United Kingdom

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O1

Ventilatory efficiency in arm ergometry cardiopulmonary exercise testing (CPET)

Dr Joanna Shakespeare[1]

[1] *UHCW NHS Trust, Coventry, Coventry*

Introduction: Arm ergometry (AE) is an alternative modality for the performance of cardiopulmonary exercise testing. Due to a combination of decreased muscle mass, muscle fibre type differences, lower oxygen conductance and mechanical differences in the ergometers, peak V̇O2 is known to be lower when measured by arm ergometry(1).

However, parameters that assess ventilatory efficiency play an important role in diagnostics and little is known about the impact of AE exercise on these parameters. The aim of this study was to compare VE/VCO2 slopes obtained by both AE and cycle ergometry (CE).

Methods: Maximal CPET to volitional exhaustion was performed in a group of 116 (62 F) healthy volunteers of median age 38 (IQR 19) years, using both AE and CE with randomised testing order and a rest interval of at least 24 hours. Breath by breath gas analysis was performed using the Ultima CPX (Medical Graphics, UK) metabolic cart.

Statistical analysis, including Pearson correlation and paired t-test were undertaken using IBM SPSS Statistics 27.0.1.0 statistical software (IBM Corporation). Ethical approval was granted by the Health Research Authority, Wales REC 7 (REC Reference 17/WA/0284; IRAS Project ID 226248).

Results: The VE/VCO2 slope was significantly higher when obtained by AE and was >30 in 84/116 (72%) of healthy volunteers, despite a significant correlation (r=0.554; p<0.001), Table 1. Ventilation when exercising with the arms is influenced by a reduced breathing frequency and a reduced peak tidal volume. In addition, there is a significantly lower CO2 output when exercising with the arms.

	Arm Ergometry (SD)	Cycle Ergometry (SD)	Mean Difference	Z score
VE/VCO2 slope *ml.in*$^{-1}$	32.56 (4.73)	28.43 (3.78)	4.12**	1.00
VT *rest L*	0.74 (0.24)	0.82 (0.28)	-0.08**	-0.38
VT *peak L*	1.98 (0.60)	2.40 (0.69)	-0.42**	-1.31
BF *rest bpm*	14.33 (4.23)	13.90 (4.02)	0.44	0.13
BF *peak bpm*	38.20 (10.21)	40.96 (8.56)	-2.76*	-0.28
VCO_2 peak *ml.min*$^{-1}$	2103.20 (4.73)	3055.29 (3.78)	-952.09**	-0.78

Data expressed as mean and standard deviation (SD)
* p<0.01; ** p<0.001; Z score = standardised test statistic

Table 1: Ventilatory parameter data obtained from arm ergometry and cycle ergometry exercise testing.

Conclusions: Recognised normal ranges for ventilatory parameters may not be appropriate when exercising with the arms. The mechanical restraints of exercising with the upper body leads to a decrease in peak tidal volume and breathing frequency and a lower CO2 output altering the relationship between VE/VCO2.

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O2

Quality Assurance in a Respiratory Laboratory: How compliant are you?

Mr Calvin Apen[1], Mr Muhammad Ifraan Khan[1]

[1] *York & Scarborough NHS Foundation Trust, Doncaster, United Kingdom*

Introduction: This study attempts to scrutinize the real-world adherence to a biological control and linearity program within an operational respiratory laboratory, where weekly designated time is allocated. The aim was to establish a local benchmark for performance monitoring and audit, taking account of reasonable workplace considerations. that was both reasonable and attainable, thereby providing a comparative reference for future assessments of compliance.

Methods: The records encompassing 3 years (July 2020 to June 2023) of QA examinations were extracted from the Pulmonary Function Testing software. Subsequently, these records underwent comparison with their respective predetermined dates for both Biological Control and Linearity checks. A permissible variance of ±7 days was employed in relation to the scheduled dates for the completion of both checks. Non-compliance dates were tallied and scrutinized to identify reasons (clinical duties, training, staffing, bank holidays etc).

Absolute compliance was calculated and defined as the ratio of all executed examinations compared to the predetermined dates for QA checks. Adjusted compliance was similarly calculated, although the predetermined dates were corrected for reasonable causes of non-compliance. These were classified as; staffing, bank

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holidays, clinical duties, equipment maintenance, conference attendance.

Results: When adjusted for reasonable circumstances, biological control checks demonstrated rates of 72% (2020-21), 78% (2021-22), and 87% (2022-23). In contrast, linearity checks exhibited higher rates of 86%, 97%, and 99% during the corresponding years. Dates of non-compliance with no articulable reason were 9.6%, 1.92% and 0% in respective years. The results indicate an improvement in compliance and the execution of QA procedures over the three-year period.

Discussion: This study highlights that designated time for QA activities within a working department result in a relatively high compliance rate. Staffing emerged as a primary factor influencing non-compliance, suggesting potential mitigation in centres with increased personnel. Notably, the study does not delve into the intangible aspect of the department's culture regarding the perceived significance of QA. Recording QA execution and establishing a shared understanding of the importance and rationale behind QA among all staff members is posited as a strategy likely to foster a sense of collective responsibility, potentially enhancing overall compliance within the team.

O4

Could the 6-Minute-Walk-Test be shortened in duration and still capture significant oxygen desaturations in patients with interstitial lung disease?

Miss Lucy Robertson[1]

1Royal Papworth Hospital, Cambridge,

Background: The 6-Minute-Walk Test (6MWT) is clinically used to detect oxygen desaturation on exertion. Peripheral oxygen saturation (SpO2%) dropping below 90% during the 6MWT is an eligibility criterion for ambulatory oxygen therapy according to British Thoracic Society guideline (2015). Shorter walk test durations could be advantageous in patients with more severe interstitial lung disease (ILD) unable to meaningfully complete a 6MWT and in remote monitoring settings (Robertson et al. 2024).

Aims: 1) To compare SpO2% recorded during different time periods of the 6MWT and the prognostic implications. 2) To determine the median time to desaturation event (SpO2% < 90%) and whether severity of ILD affects this.

Methods: Retrospective routine clinical 6MWT and lung function data were collected from patients with ILD. Median lowest SpO2% recorded in the first time period (0-2 mins), middle time period (2-4 mins) and last time period (4-6 mins) of the 6MWT were statistically and prognostically compared. Patients were classified according to the Distance-Oxygen-Gender-Age-Physiology (DO-GAP) index (Chandel et al. 2023)

Results: 258 patient records were analysed. Median (IQR) SpO2% recorded at 0-2, 2-4 and 4-6 minutes of 6MWT were 93% (8), 92% (8) and 91% (10) respectively and were significantly different between time periods($p<0.001$). Prognostically, areas under the curve (AUC) for predicting 3 year mortality were significant ($p<0.001$) and similar for the lowest SpO2% recorded between 0-2, 2-4 and 4-6 minutes of the 6MWT (AUC = 0.71, 0.72 and 0.71, respectively). 107 patients had significant desaturation (SpO2% <90%) during the 6MWT, of whom 14 were already walking with ambulatory oxygen therapy. Kaplan Meier analysis demonstrated the median time for SpO2% to fall below 90% ranged from 1.5–3 minutes between the DO-GAP groups (p=0.01 figure 1).

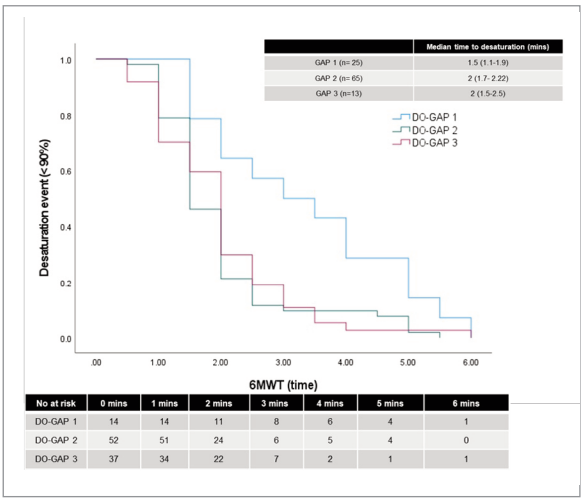

Figure 1. Kaplan Meier analysis of time to desaturation event for n=103 patients with ILD who all desaturated to <90% by the end of a 6MWT. Patients are categorised into the three strata of the DO-GAP severity index

Conclusion: For patients with ambulatory oxygen desaturation during a 6MWT, the SpO2% generally falls below 90% early in the test. For example, a 3MWT has over 80% sensitivity for identifying ambulatory oxygen desaturation in more severe ILD (DO-GAP groups 2 and 3). Shorter walk test durations could be used to detect oxygen desaturation in patients with ILD which would be more efficient, more patient-centred and more compatible with remote exercise testing.

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P2

The Assessment of Respiratory Entropy in Chronic Obstructive Pulmonary Disease Using Structured Light Plethysmography

Miss Megan Walton[1], Dr James Stockley[1], Mr Eyas Alhuthail[1], Dr Andrew Coney[1], Prof Brendan Cooper[1]

[1]University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK, [2]University of Birmingham, Birmingham, UK

Introduction: Spirometry is the gold standard for diagnosing COPD. However, its insensitivity to small airways and early disease, and demanding volitional manoeuvres have resulted in ongoing interest into alternative methods of assessment that only require tidal breathing. We sought to determine if measures of respiratory entropy ("regularity" of breathing) from structured light plethysmography (SLP) could be useful in the diagnosis of COPD.

Method: 18 participants with varying severities of COPD were recruited. SLP (PneumaCare, Cambridge, UK) was performed before and after 2.5mg of salbutamol, followed by spirometry if not previously completed within 6 months. Entropy data were calculated using LabChart 8 (AD Instruments Ltd, 8.1.24) in four ways; as root mean squared of successive difference (RMSSD; variability from one breath to the next) and standard deviation (SD; overall variability) for both breath-to-breath interval (BB) and tidal volume (VT). Entropy was compared to spirometry (FEV1/FVC, FEV1 z-score, FEV1 %pred) using Spearman's Rank Correlation. Pre- and post-salbutamol entropy in COPD was compared using a Wilcoxon Signed-Rank test. COPD data was compared to data from 13 healthy participants (previously tested in a separate study) using a Mann Whitney-U test. All analyses were undertaken using IMB SPSS (version 24) with $p<0.05$ as the threshold for statistical significance. The study was sponsored by PneumaCare® (REC Reference 21/YH/0004).

Results: No correlations were found between any SLP entropy and spirometry parameters in COPD. There were no significant differences observed in any entropy parameter following bronchodilation. However, there were significant differences between entropy post-bronchodilation in COPD and health; SDBB (p=0.011), RMSSDBB (p=0.025), SDVT (p=0.001), and RMSSDVT (p=0.011). Some differences were also observed pre-bronchodilation in COPD compared to health; RMSSDVT (p=0.042) and SDVT (p=0.010), although RMSSDRATE was

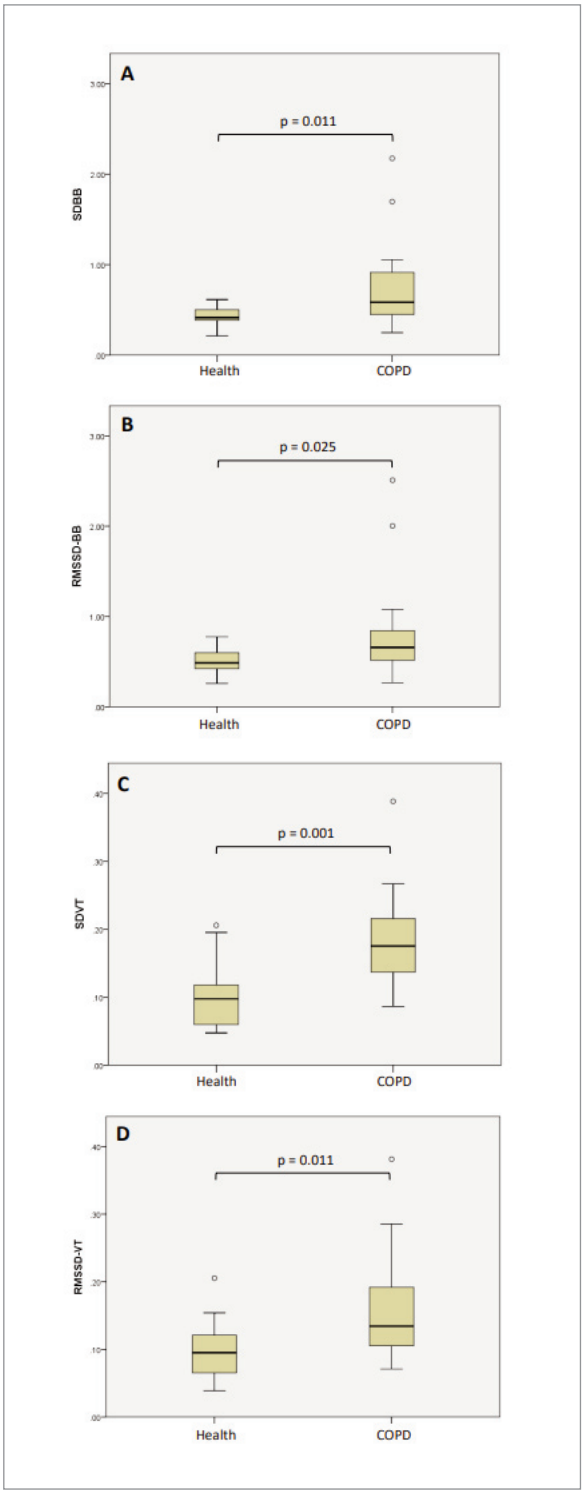

Figure 1. Box & Whisker plots of entropy in health (n=13) versus (COPD post-bronchodilator (n=18), derived by 4 methods; A: SD_{BB} (p=0..011), B: $RMSSD_{BB}$ (p=0.025), C: SD_{VT} (p=0.001), D: $RMSSD_{VT}$ (p=0.011). Boxes are median +/- interquartile range (IQR) with whiskers set at 1.5 x IQR

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not different (p=0.106) nor was SDBB (p=0.051), although a power calculation for the latter suggested it was underpowered by only 5 participants.

Conclusion: Although SLP entropy does not correlate with spirometry in this pilot study, it appears greater (hence, less regular) in COPD post-bronchodilator compared to health and could, therefore, prove useful diagnostic tool with more data. However, it does not appear to be useful in bronchodilator reversibility testing.

P4

OSCILLOMETRY IN ROUTINE LUNG FUNCTION TESTING: A UK-BASED SURVEY

Miss Madison Geeves[1], Dr Harry Griffin[1], Dr Michael Hughes[1], Dr Karl Sylvester[2], Dr Lindsay Welch[3], Dr Zoe Saynor[4]

[1]Hampshire Hospitals NHS Foundation Trust, England, [2]Royal Papworth Hospital NHS Foundation Trust, Cambridge, England, [3]Bournemouth University and University Hospitals Dorset NHS Foundation Trust, Bournemouth, England, [4]University of Portsmouth, Portsmouth, England

Introduction: Oscillometry is used to assess lung function during normal tidal breathing. Although it offers potential advantages over spirometry and has been available for many years, adoption into clinical practice anecdotally seems slow. This online survey aimed to investigate 1) the prevalence of oscillometry within respiratory services in the UK, 2) understand the reasons for utilisation and 3) the barriers to adoption of the technique.

Method: This survey formed part of a larger project supported by the National Institute for Health and Care Research Applied Research Collaboration Wessex, and was approved by the University of Portsmouth ethics committee. It was disseminated electronically to all Association for Respiratory Technology and Physiology (ARTP) members and further distributed via LinkedIn and X. Quantitative data was analysed and presented as frequency statistics. For qualitative data, free-text comments were analysed for common themes.

Results: 42 NHS respiratory services completed the survey. 17 (41%) services indicated they own an oscillometry device; eight with a forced oscillation technique device (ResMon Pro), eight with an impulse oscillometry device (Vyntus IOS), one with both. Of the 14 services currently using oscillometry for clinical testing, eight (57%) test on adults, three (21%) on paediatrics, and three on both. All 14 services reported using oscillometry for patients with asthma, and eight (57%) for chronic obstructive pulmonary disease. 12 (86%) services use it for patients who cannot perform technically acceptable spirometry. Of the 24 services currently without a device, 12 (50%) indicated they would consider purchasing one within the next five years, with lack of funding being the main barrier in eight of the remaining 12 (67%). Four (10%) and 36 (86%) services perceived respiratory consultants' understanding of oscillometry to be 'none' or 'little', respectively. 40 (95%) reported a publication from the ARTP, outlining the benefits/limitations and/or guidance on reporting, would be beneficial.

Conclusion: Oscillometry is being used within some respiratory services across the UK, predominately for patients with asthma and those who cannot perform technically acceptable spirometry. The next step is to liaise with the ARTP and discuss supporting the potential development of national standards of oscillometry and a guidance publication.

P5

It's not all about Asthma! The prevalence of alternative diagnosis in patients with confirmed or suspected asthma.

Mrs Megan Robshaw[1], Mrs Emma Raywood[1], Mrs Helen Parrott[1]

[1]NuvoAir Clinical Service, United Kingdom

Introduction: Asthma can be over or under diagnosed in patients reporting respiratory symptoms (Aaron et al. AJRCCM 2018; 198: 1012-20). Alternative diagnoses such as inducible laryngeal obstruction (ILO) or breathing pattern disorder (BPD) mimic asthma symptoms and can be challenging to identify (Williams et al. ERJ Open Res 2023; 9: 00635-2023). The aim was to review the prevalence of alternative diagnoses in patients with confirmed or suspected asthma who completed the NuvoAir home assessment.

Methods: Outcome and engagement data was collected and analysed from patients referred to the 12 week NuvoAir home assessment service from December 2021 to November 2023. Patients were on boarded by respiratory physiologists who coached them to perform quality assured spirometry four times weekly and when symptomatic. Symptom history was recorded and Nijmegen and/or VCD questionnaires completed if BPD or ILO were suspected. Post assessment a report was

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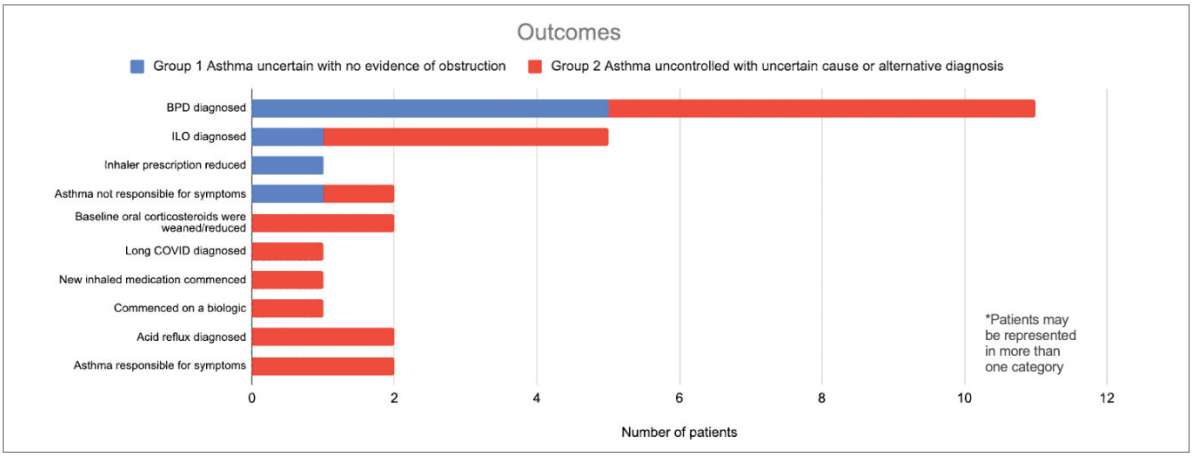

Figure 1. Clinical outcomes of home spirometry assessment

generated with results, interpretations and recommendations. NHS clinicians facilitated onward referral and outcomes were gathered. An experience questionnaire was sent to patients.

Results: Of 75 patients referred, 21 individuals (28%, age 43.7 (±11.7) years; 4 Male, 17 Female) had a concurrent diagnosis suspected at referral. Average engagement to 4 times weekly spirometry was 84% with 73% of sessions graded A-C (ATS 2005). Overall 25% of patients were diagnosed with ILO and 55% diagnosed with BPD (Figure).

Two subgroups emerged; group 1 asthma uncertain with no previous evidence of obstruction (n=7) and group 2 uncontrolled asthma with uncertain cause (n=14). In group 1 asthma was disproven for all. In group 2; asthma was disproven in one individual, asthma was solely responsible for symptoms in two and 11 individuals received an additional diagnosis (Figure 1). When surveyed, 75% of patients thought the NuvoAir assessment was useful in detecting drops or improvements in their lung function, understanding patterns of their health and providing them with reassurance.

Conclusion: In this cohort of patients with uncontrolled or unconfirmed asthma, a physiologist-led home assessment utilising serial spirometry measures, validated questionnaires and detailed history taking has enabled an accurate diagnosis of asthma and facilitated the timely identification of BPD and ILO.

P7

Immediate and 3-month tolerance of nebulised Sodium Colistimethate to treat pseudomonas infection/colonisation in patients with non-CF bronchiectasis.

Mr Richard Glover[1], Dr. Nichola Sinden, Dr. Julie Lloyd

[1]*University Hospitals Birmingham, United Kingdom*

Introduction: Nebulised Sodium Colistimethate (SCM) is recommended as an off license treatment in the British thoracic society guidance to manage Pseudomonas Aeruginosa (PA) colonisation in patients with non-cystic fibrosis (CF) bronchiectasis. In non-CF bronchiectasis, PA colonisation is associated with increased mortality, risk of hospital admission and exacerbation. Despite the evidence, use of nebulised antibiotics is not without risk with bronchospasm a known side effect, occurring in approximately 7-10% of patients undergoing nebulised antibiotic therapy.

Aim: Nebulised SCM is offered in the local service, but tolerance has not been previously assessed in this cohort. The aim of this study is to review patients undergoing trials of nebulised SCM to identify potential risk factors and mitigating strategies to reduce the incidence of intolerance.

Methods: Patients who underwent SCM challenge test between January 2019 and June 2023 were included. Spirometry data was obtained and the pre-and post (nebulised SCM) was reviewed for the incidence of bronchospasm (defined as a fall ≥15% FEV1). In subjects who did not show an initial adverse reaction, tolerance and PA clearance was assessed at 3 months.

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Results: 60 patients were included (F=43 (72%), mean: 71). 7 (13%) had an adverse reaction during SCM challenge test. 53 proceeded to a 3-month trial of nebulised SCM; 33 (55% of the total cohort; 62% of the remainders) successfully completed the course, 16 (27% of the cohort, or 30% of the remainders) ceased due to intolerance, 1 patient was unable to comply due to dementia associated cognitive decline and 3 patients were lost to follow up.

Discussion: 38% were unable to tolerate the 3-month SCM treatment course either due to initial bronchoconstriction or later suspected treatment-related adverse effect. The frequency of adverse effects was lower than that identified in a recent RCT but many of the side effects in the clinical trial were attributable to other cause and fewer patients stopped the treatment than in our cohort (7% vs. 45%). It was difficult to determine the time point at which the treatment was ceased and the exact reasons why in this study as almost all patients had ceased treatment before their clinic review.

P8

Comparison of dead space estimates using Fowler and Cotes sampling methods during gas transfer.

Miss Lucy Robertson, Dr Karl Sylvester

[1]Royal Papworth Hospital, Cambridge, United Kingdom

Background: Anatomical dead space can be calculated using different methods. Cotes method estimates dead space utilising bodyweight (2.2 ml x kg). The Fowler technique measures dead space utilising the tracer gas washout curve.

Aims: To compare TLCO between dead space calculation methods (Fowler and Cotes) using the set discard and sample volume option.

Methods: TLCO was measured using the Master Screen (Vyaire) rapidly responding gas analyser and the single breath method. Settings were changed retrospectively to compare the impact of dead space calculation methods on past TLCO results. Discard and sample volumes were set at 900 ml and 600ml respectively for both methods. Gas transfer parameters and dead space values between methods were compared statistically using paired t-tests or Wilcoxon rank sum tests. Z-score classifications were also compared between methods. Difference in agreement between dead space methods was compared using Bland-Altman method to calculate the bias (Fowler dead space – Cotes dead space). Linear regression was used to test for any change in the bias with change in dead space scale range.

Results: TLCO results are presented in table 1 from 53 patients comparing methods. TLCO and VA values were significantly different between methods. Several patients changed z-score severity class depending on method used. Anatomical dead space was significantly higher using the Fowler method compared with Cotes ($p<0.001$). The calculated bias between dead space methods was -100.5 ml ±64.9(26.8 to – 227.8 ml). There was a significant systematic change in bias with change in scale with dead space ($r = 0.69$ $p<0.001$) which indicates the difference in values between dead space methods was higher in the higher ranges of dead space.

Conclusion: Calculation of TLCO using Cotes and Fowler methods with set option for discard and sample volume produce significantly different outcomes resulting in a difference in classifications of abnormality. Anatomical dead space was significantly higher using the Fowler method. Future investigations should investigate the impact of automatic discard volume determination setting when using different anatomical dead space methods.

(n=53)	Fowler	Cotes	Significance
TLCO (mmol/min/kpa)	4.77 (2.85)	4.90 (2.86)	***
TLCO pred. (%)	66 ± 24	69 ± 24	***
TLCO z score	-2.47 ± 1.85	-2.27 ± 1.78	***
VA (litres)	4.05 ± 1.33	4.23 ± 1.31	***
VA pred. (%)	77 ± 19	80 ± 18	***
VA z score	-2.11 ± 1.67	-1.78 ± 1.56	***
KCO	1.22 ± 0.36	1.22 ± 0.36	
KCO pred (%)	85 ± 0.60	85 ± 0.60	
KCO z score	-0.89 ±1.51	-0.89 ±1.51	
TLCO Z score classification	Normal (n=27) mild (n=5) moderate (n=9) severe (n=15)	Normal (n=23) mild (n=6) moderate (n=16) severe (n=9)	***
Discard volume (litres)	0.91(0.02)	0.91 (0.02)	
Sample volume (litres)	0.59 (0.02)	0.59 (0.02)	
Anatomical dead space (ml)	244(104)	150(34.7)	***

Table 1: Comparison of Fowler and Coates method values. *** p<0.001 data presented as mean (± SD) or median (IQR)

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P9

The suitability of obtaining a single acceptable gas transfer result

Mr Joshua Barnes[1], Miss Heather Nuttall[1], Mr Andrew Collingwood[2], Dr Karl Sylvester[1,3]
[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, UK, [2]Counties Manukau, Te Whatu Ora, Auckland, New Zealand, [3]Cambridge University Hospitals, Cambridge, UK

Introduction: The single-breath gas transfer test assesses the lung transfer factor of carbon monoxide (TLCO) and is routinely used in clinical practice for monitoring chronic respiratory conditions. The ARTP recommend achieving two acceptable and reproducible results, with the mean being reported (Sylvester et al., 2020). It is unknown whether obtaining one acceptable manoeuvre is sufficient.

Methods: 200 patients from June 2023, who performed gas transfer testing from the following clinical specialities were reviewed: Interstitial Lung Disease, Pulmonary Vascular Disease, Oncology and Lung Defence. Testing was conducted using Vyaire equipment in accordance with ARTP 2020 guidelines, and GLI 2017 reference values were utilised (Stanojevic et al., 2017). ARTP 2020 z-score thresholds were used to classify the severity of abnormalities. A one-way ANOVA was used to assess for differences between manoeuvres, and sub-analyses were conducted to account for clinical specialities and spirometry patterns.

Results: 25 patients (12.5%) achieved one acceptable result and 14 (7.0%) achieved no acceptable results. Of those 39 patients, 23 declined further testing, 10 performed maximal attempts, 5 did not meet VIN criteria and 1 patients' testing was stopped prematurely due to safety concerns. In the remainder of the cohort, it took a median 3 attempts to obtain 2 acceptable and reproducible results. Of the 161 patients who performed a minimum of two acceptable manoeuvres, 138 (85.7%) met ARTP reproducibility criteria within the first two manoeuvres, while 4 patients (2.5%) failed to meet reproducibility criteria. There was no statistical difference between acceptable manoeuvres for TLCO, KCO or VA ($p<0.05$). When accounting for clinical specialities or spirometry pattern, all results were comparable and non-significant ($p<0.05$). Changes in TLCO, KCO and VA, and the proportion of patients whose grading severity changed between manoeuvres are seen in Table 1.

		Absolute difference	% Predicted difference	Z-Scores difference	Change between Normal and Abnormal Classification	Change in Grading Severity
1st vs 2nd acceptable manoeuvre	TL_{CO} (mmol/min/kPa)	0.04 (0.32)	0.61% (4.37%)	0.06 (0.36)	4 (2.5%)	18 (11.2%)
	K_{CO} (mmol/min/kPa/L)	0.01 (0.06)	0.78% (4.09%)	0.05 (0.29)	3 (1.9%)	14 (8.7%)
	VA (L)	0.00 (0.20)	0.00% (3.59%)	0.00 (0.33)	4 (2.5%)	18 (11.2%)
1st acceptable manoeuvre vs reported value	TL_{CO} (mmol/min/kPa)	0.04 (0.17)	0.48% (2.36%)	0.06 (0.20)	3 (1.9%)	11 (6.8%)
	K_{CO} (mmol/min/kPa/L)	0.01 (0.03)	0.51% (2.31%)	0.04 (0.16)	1 (0.6%)	11 (6.8%)
	VA (L)	0.00 (0.09)	-0.02 (1.75%)	0.00 (0.16)	0 (0.0%)	26 (16.1%)

Data reported as median (Interquartile range)

Table 1:

Conclusion: In 86% of cases, one acceptable manoeuvre provided the clinical information required. There were negligible differences in results between acceptable manoeuvres and few patients changed gas transfer grading. These results highlight the suitability of using the first acceptable gas transfer result, questioning the requirement for routinely obtaining two acceptable and reproducible gas transfer results.

P10

Cetrospective audit analysing the effects of applying the Global Lung Initiative (2021) reference ranges on static volumes for Non-Caucasian population

Ms Manisha Perera[1], Ms Lauren Kimberley[1], Mr Mark Unstead, Dr Adrian Kendrick[2]
[1]Royal Berkshire Hospital, Reading, United Kingdom, [2]University of West of England, Bristol, United Kingdom

Introduction: The introduction of the Global Lung Initiative (GLI (2021) reference values for static volumes has allowed for a more statistically valid and representative interpretation of lung volumes.

Recent guidance encourages the use of more up to date reference ranges, although there is limited research on the impact of adopting the current GLI equations in a Non-Caucasian subjects.

The aim of this study was to assess the impact of adopting the GLI equations for static volumes in an adult Non-Caucasian population of Berkshire.

Method: A retrospective audit was performed using data from Non-Caucasian (NC) and Caucasian (C) patients (as a control), which were changed from ECSC (1993) to GLI reference values.

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The NC group (n=100) consisted of 50% male/female with a mean age 56.4 years (range 21-79 years), height 166cm (142-187cm) and BMI of 28 kg/m2 (18-45 kg/m2). The C group (n=100) were matched accordingly.

Changes in predicted values and z scores for TLC, FRC, RV, and VC MAX were tested for statistical significance with the appropriate difference test. Changes in severity of clinical abnormality was assessed with interrater agreement testing.

Results: VC MAX, TLC, RV and FRC for the NC group, had statistically significant mean differences for predicted values and z-score ($p<0.001$) when moving from ECSC to GLI datasets.

Significant differences were found between the NC and C group for changes in z-score when using GLI for VC Max ($p<0.01$), FRC ($p<0.01$) and RV ($p<0.05$).

There was an increase in severity score for NC patients for VC Max, with the frequency of patients who were classified as normal reducing from 81 to 33. TLC also showed a change, the frequency of normal classification reducing from 68 to 40. The C group showed a similar pattern of severity shift but with less statistical significance

Conclusions: The adoption of the GLI reference equations for a non-Caucasian population of Berkshire result in significant changes when interpreting static lung volume results compared to a Caucasian control group. This data would suggest non-Caucasian populations are potentially more affected by implementation of new prediction models.

P12

Exploring physiological discordance between spirometry and gas transfer in idiopathic pulmonary fibrosis (IPF)

Miss Absari Choudhury[1], Dr Joanna Shakespeare[1], Prof David Parr[1]

[1]*University Hospital Coventry & Warwickshire, Coventry, United Kingdom*

Introduction: FVC is used as the index for monitoring, commencing anti-fibrotic treatment and as an outcome measure in IPF but may not reflect the full physiological impact of disease. Gas transfer measures the alveolar/capillary changes however, these values can be discordant to spirometry values. The reason for these discordant values in IPF is not currently understood and this may have an impact on clinical management.

Method: Retrospective analysis of full PFTs in 207 IPF patients were conducted and indices were compared by Pearson correlation. Of these, 32 patients were identified with discordant FVC and KCO values. These were further categorised as being either volume impaired (VI) with an FVC:kCO ratio ≤1.3 or Diffusion Impaired (DI) with an FVC:KCO ratio of ≥4.

HRCT of these discordant patients were visually assessed, and quantifications made for the level of honeycombing and reticulation/ground glass changes1. The presence of emphysema and pulmonary hypertension were also assessed. Comparison of groups was made by independent t-test.

Results: In the full cohort, the mean (SD) age was 75.15 (8.30) years, smoking exposure 19.00 (34.30) pack years, BMI 28.29 (4.69) kg/m2 and male:female 155:52.

Spirometry demonstrated restriction with reduced FVC (77.56% predicted), preserved FEV1/FVC ratio (0.83) and impaired gas transfer (TLCO 56%, VA 67% and kCO 82% predicted). Statistically significant relationships were evident between FEV1 and FVC, and all gas transfer parameters ($p<0.01$).

Data of the 32 discordant patients are summarised in Table 1 with no significant difference in demographics between groups. CT scans did not show any significant differences in interstitial abnormalities or presence of pulmonary hypertension however, emphysema was only present in DI group.

	Group VI (n=16) Mean (SD)	Group DI (n=16) Mean (SD)	Significance
Age (years)	76.44 (8.89)	77.94 (8.80)	NS
BMI (kg/m^2)	27.88 (5.64)	30.81 (17.24)	NS
Sex (M:F)	5:11	16:0	
Smoking history (pack years)	11.06 (25.86)	24.97 (20.33)	NS
Presence of Emphysema (%)	0	50%	0.001
Mean score for honeycombing			
Upper zone	1.06 (0.44)	1.19 (0.54)	
Middle zone	1.31 (0.48)	1.56 (0.81)	
Lower zone	1.75 (0.68)	1.88 (1.15)	
Mean score for reticulation/ ground glass changes			
Upper zone	1.06 (0.68)	0.69 (0.70)	
Middle zone	1.19 (0.54)	0.88 (0.62)	
Lower zone	1.25 (0.58)	1.50 (0.73)	

Table 1: Comparison of VI and DI groups

Conclusions: Whilst VA closely correlates with FVC and reflects restriction severity, kCO reflects the diffusion impairment and therefore, this provides more specific information about alveolar/capillary impairment than TLCO.

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Whilst there were 2 distinct discordant groups with physiological differences seen, the extent of interstitial abnormalities were similar in both groups. Coexisting emphysema rather than pulmonary hypertension may account for DI phenotype.

Reference

1. Larsen1Sverzellati N et al. Visual score and quantitative CT indices in pulmonary fibrosis: relationship with physiologic impairment. Radiol med. 2007:112:1160-1172

P13

Evaluation of pre-bronchodilator FEV1/VCMax z-score in the context of significant bronchodilator response in patients with an FEV1/VCMax z > -1.645

Mr Dominic Evans[1], Mr Muhammad Irfaan Khan

[1]*York Teaching Hospital NHS Trust, York, United Kingdom*

Introduction: Bronchodilator responsiveness (BDR) during reversibility may be possible even without the presence of airflow obstruction (AFO). Over two decades the definition of AFO and what constitutes a 'significant' BDR has led to some differences in practice. This study aims to reaffirm the importance of considering reversibility in normality and considers borderline AFO as being distinct to normal based on FEV1/VCMax. This distinction is anticipated to reopen debates regarding the implementation of guidelines, and the performance of reversibility, which is often limited to patients with defined AFO.

Methods: A retrospective analysis of reversibility was taken in an 18 month 'post-COVID-19' cohort, where BDR was seen despite normal baseline FEV1/VCmax ratio (n=78, Male=28, Female=50, Adults=69, Paediatric=9, Caucasian = 76, Black = 1, Other/Mixed = 1). Patients were categorised into a 'Borderline' and 'Normal' group (determined by an FEV1/VCMax Z-score of -1.645<Z<-1.282 and Z>-1.282 respectively), and analysed against ARTP, ATS/ERS and NICE reversibility guidelines. T-tests were performed to assess degree of BDR between borderline and normal groups.

Results: BDR was most identified in patients by ARTP (2020) guidance (n=78); of these, 31 were positive according to ATS/ERS (2021), 28 by NICE/BTS (2019) and 27 by ATS/ERS (2005). Twenty-four of the 78 ARTP-identified positive responses were in the 'borderline' group (31%), 45% were in 'borderline' when using ATS/ERS (2021), 35% when using NICE/BTS (2019) and 29% when using ATS/ERS (2005). Independent sample t-tests yielded no statistically significant difference in the mean for FEV1 %improvement, raw improvement (ml), nor FEV1 %predicted improvement.

Conclusion: The results indicate the ATS/ERS (2005) guidance to be the most conservative while ARTP (2020) the least, when determining a significant BDR. Irrespective of the guidance applied, most patients showing significant BDR were not 'borderline'. However, 45% of patients belonging to the 'borderline' group when applying the ATS/ERS (2021) guidance may suggest an important Z-score window, that yields a high number of positive responses from a relatively small range of Z-scores. Using Z>-1.282 could prove an efficient compromise, aiming to minimise missing significant responses whilst avoiding over-administrating bronchodilators, were the threshold of -1.645 to be applied when indicating BDR studies.

P14

Is the Forced Oscillation Technique a suitable surrogate for more volitional lung function testing in COPD?

Miss Ella O'Neill[1], Dr Ben Knox-Brown[2], Dr Karl P Sylvester[1, 2]

[1]*Cambridge University Hospitals, Cambridge, United Kingdom,* [2]*Royal Papworth Hospital, Cambridge, United Kingdom*

Background: The forced oscillation technique (FOT) has been intensively researched for use in patients with respiratory disease. However, since then the technology has progressed and its uses within respiratory testing have increased. This study aims to identify if FOT measurements can be used to identify pathology associated with chronic obstructive pulmonary disease (COPD) in comparison to more volitional lung function assessments.

Methods: FOT was performed using Resmon Pro (Restech Milano, Italy), spirometry and body plethysmography were performed using Jaeger Masterscreen (Vyaire Medical, Germany) in 6 patients (2 female, age 67.1years ± 5.7, height 170cm ± 12.7 and weight 74.3kg ± 14.4) with a known diagnosis of COPD as part of a clinic visit in November 2023. Results have been analysed using Pearson's correlation to determine the relationships between measurements.

Results: Analysis identified a strong (R= 0.9473) significant (P=0.004093) correlation between RV/TLC ratio standard residual (SR) and AX inspiration SR (Figure 1). Other correlations were identified but none were significant.

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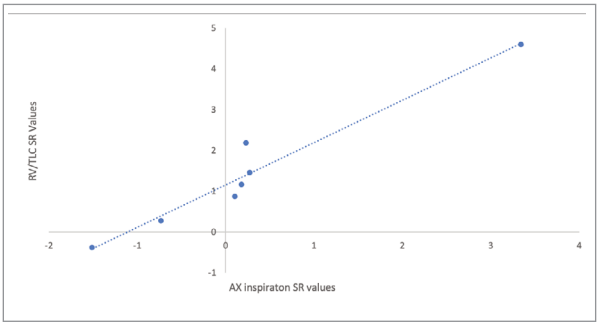

Figure 1. Comparison of lung function and FOT measurements from 6 patients with a confirmed diagnosis of COPD. AX inspiratory measuring the elastic [roperties of the lung and increases in conditions impacting the lung periphery

Conclusion: When analysing the relationship between AX (area under the reactance curve) during inspiration and the RV/TLC ratio, a strong and significant correlation can be found identifying its potential use for identifying and severity grading lung gas trapping in patients with COPD.

Additional further research to greater identify the specificity and sensitivity of these tests against already established markers of pathophysiology in a larger cohort is warranted

P15

A retrospective review of home-based spirometry quality in an adult lung transplant cohort

Mr Bryn Williams[1], Miss Rebecca Borton[2], Dr Caroline Patterson[1], Dr Karl Sylvester[1,3]

[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]patientMpower, [3]Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

Introduction: Lifelong surveillance of lung transplant (LTx) recipients is essential for the detection of allograft complication and early detection may improve patient outcomes (Odisho et al, 2023). Regular home and hospital spirometry are part of routine monitoring, with home spirometry highly correlated with hospital spirometry (Wijbenga et al, 2020).

The introduction of artificial intelligence-based software (ArtiQ.QC) to a remote monitoring program (patient-facing app & Bluetooth-connected spirometer) allowed spirometry efforts to be assessed against international standards (Graham et al, 2019) and provided automated feedback to patients.

Home spirometry, of sufficient quality, could support the identification of complications, clinical decision making, and reduce the patient burden. An understanding of the data quality, ensuring results are useful and reproducible is required.

Methods: Lung transplant recipients, consenting to a remote monitoring program, were asked to perform spirometry measurements daily in year 1, reducing to twice weekly and weekly when deemed clinically appropriate.

65 patients provided home spirometry data from 1/10/2022 to 30/09/2023. From 1/4/2023 patients received automated feedback and spirometry was graded according to 2019 ATS/ERS criteria (Graham et al, 2019) via ArtiQ.QC. Data collected prior to 1/4/2023 was retrospectively graded using ArtiQ.QC.

We retrospectively analysed the quality of spirometry sessions pre- and post- the introduction of ArtiQ.QC.

Results: There was no change in the percentage of A graded sessions in the 6 months post introduction of ArtiQ.QC, and an increase in the percentage of E and F graded sessions. Additional analysis highlighted 49% (352) of post ArtiQ.QC E and F graded sessions were recorded by only 2 patients.

Number of Spirometry Sessions	6-months prior to introduction of quality feedback	6-months post introduction of quality feedback
Total Sessions	1,773 (6409 blows)	1,536 (7659 blows)
A Graded (≥3 Acceptable within 0.150L*)	681 (38%)	586 (38%)
B Graded (2 Acceptable within 0.150L*)	476 (27%)	153 (10%)
C Graded (≥2 Acceptable within 0.200L*)	35 (2%)	53 (4%)
D Graded (≥2 Acceptable within 0.250L*)	16 (1%)	33 (2%)
E Graded (≥2 Acceptable > 0.250L or 1 acceptable)	351 (20%)	370 (24%)
F Graded (0 Acceptable or ≥0 usable)	213 (12%)	341 (22%)
U Graded (0 Acceptable or ≥1 usable)	1 (0.05%)	0 (0%)

Table 1: Comparison of VI and DI groups

Conclusions: Good quality standards can be achieved through home-spirometry, with and without automated feedback, with appropriate support from trained respiratory physiologists. Automated quality control is useful for identifying patients struggling with home spirometry, who may benefit from intervention (e.g., video conferencing). This automated selection of patients requiring support reduces the burden of reviewing every patient unnecessarily. The impact of additional coaching for patients identified as producing a high percentage of poor-quality readings requires further investigation.

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P16

Home-based spirometry: is one effort enough?

Mr Bryn Williams[1], Miss Rebecca Borton[2], Dr Caroline Patterson[1], Dr Karl Sylvester[1,3]

[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]patientMpower, [3]Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

Introduction: Regular home and hospital spirometry are part of routine post lung transplant (LTx) monitoring. The goal is to facilitate the early detection of complications and home spirometry is highly correlated with hospital spirometry (Wijbenga et al, 2020).

The recommended goal of all testing sets is ≥3 acceptable forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) measurements, with the difference between the largest and the next largest measurement ≤0.150L (Graham et al, 2019). These recommendations were developed for diagnostic spirometry and may increase patient burden and impact adherence when using spirometry for monitoring purposes only. There are no official guidelines for home spirometry and further research is required to establish the optimal schedule for home spirometry (Maher et al, 2022).

This retrospective study assessed the quality of home spirometry sessions from post LTx patients, focusing on determining whether fewer spirometry manoeuvres would impact test session outcomes.

Methods: Lung transplant recipients, consenting to a remote monitoring program, were asked to perform spirometry measurements daily in year 1, reducing to twice weekly and weekly when deemed clinically appropriate.

In a 60-month period, 50 of 108 patients achieved 642 FEV1 A grade sessions, as determined by artificial intelligence-based software (ArtiQ.QC). These sessions were analysed to determine the number of blows performed and the number of blows taken to achieve an effort meeting A grade acceptability and repeatability criteria.

Results: Of the 642 FEV1 grade A sessions, 74.5% required ≤ 4 efforts, 18.5% required 5-6 efforts, and 7% required ≥ 7 efforts.

93% of FEV1 grade A sessions have an acceptable FEV1 in the first effort; 79% of these first efforts were within 0.150L of the highest FEV1 reading for the session.

Effort with the first accepted FEV_1 in a session	1	2	3	4	5	6
Session count	596	32	9	4	1	0

Table 1: Effort producing first accepted FEV1 in a session, as graded using ArtiQ.QC

Conclusions: When good technique has been established, one spirometry effort can produce good quality FEV1 results, potentially reducing patient burden. These findings could support guidance on the optimal schedule of home spirometry for monitoring purpose. This research would not support changes to established guidelines when performing diagnostic spirometry. Further intervention would be required for those patients not achieving spirometry with a high-quality level.

P17

A case study on the effect of keeping an African Grey Parrot: Hypersensitivity Pneumonitis.

Miss Ella O'Neill[1], Mr Christopher J Harding[1], Dr Karl P Sylvester[1, 2]

[1]Cambridge University Hospital, Cambridge, United Kingdom, [2]Royal Papworth Hospital, Cambridge, United Kingdom

Pathophysiology: Hypersensitivity pneumonitis (HP) is inflammation of lung parenchyma caused by inhaling small particles of an allergen, provoking type III and type IV hypersensitivity reactions. A subtype of HP is caused by animal exposure to the proteins within the waxy powder coating found in avian serum, faeces, and feathers. Acutely this can cause fevers, shortness of breath as well as chest discomfort for the patient.

Case Presentation: Patient (45-year-old, female, fitness instructor) presented to the emergency department with a 3-month history of worsening breathlessness and cough, oxygen saturations declining to 87% on room air. Upon initial investigation the only remarkable findings where increase inflammatory markers (mild neutrophilia and mildly raised CRP) and the patient was discharged with antibiotics. Symptoms did not improve; therefore, a respiratory referral was made. Further history taking and investigations revealed the patient owned a pet parrot, which due to traveling limited contact had been made with until the COVID19 lockdown. Patient was found to have reduced gas transfer results (TLCOc SR -3.24, VA SR -0.39 and KCOc SR -2.93) and CT-thorax revealed widespread mosaic attenuation, air trapping and patchy areas of ground glass changes.

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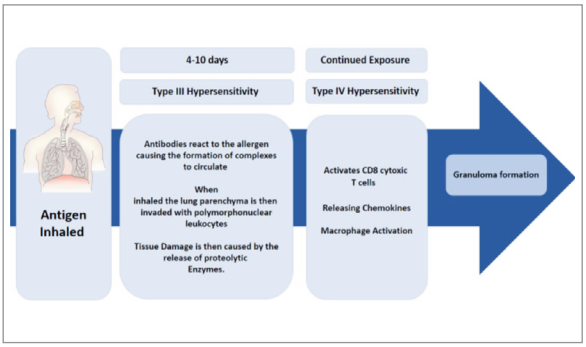

Figure 1. Pathophysiological pathway of inflammation causing hyposensitivity pneumonitis adapted from Usman and Annamaraju (2022)

Conclusion: A diagnosis of hypersensitivity pneumonitis (HP) was made, and the patient was recommended to re-home the bird. The patient's lung function then returned to within expected values and symptoms subsisted within 5 months of the antigen being removed. This recovery was swift and unpredicted, but without the quick identification and removal of the antigen, long term exposure can lead to irreversible fibrotic changes. This case study highlights the importance of identifying antigens which may be causing patient symptoms as well as the lack of awareness of the recovery time of acute hypersensitivity pneumonitis.

Reference

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P19

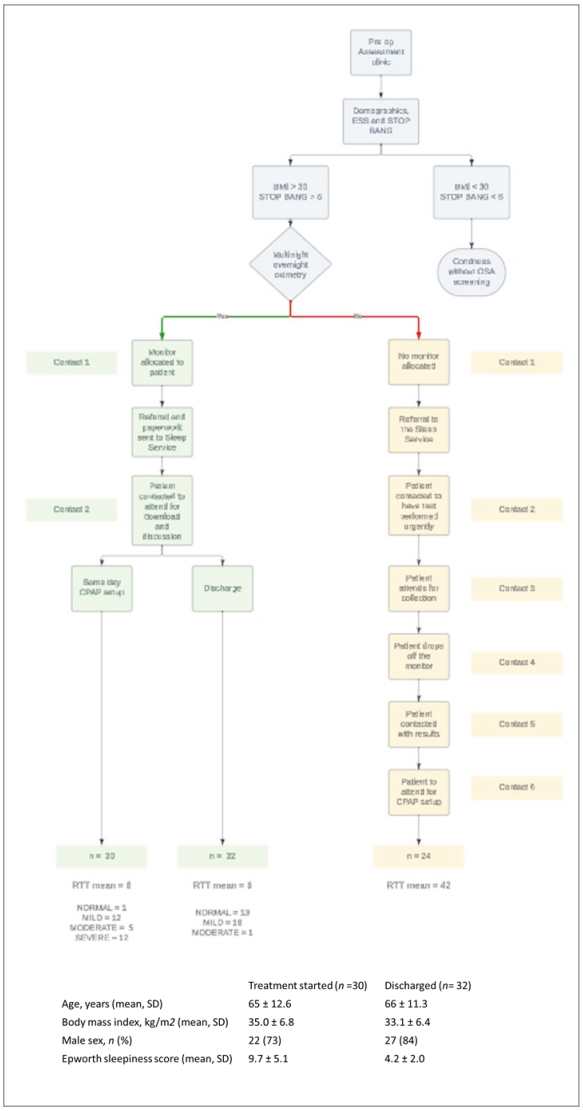
A Fast Track Pre-operative OSA Screening Pathway - Don't sleep on it!

Alice Bonham-Carter[1], Hannah Cullen[1], Shirley Coelho[1]

[1]*Hereford County Hospital, Hereford, UK*

Introduction: Obstructive sleep apnoea (OSA) is a risk factor for anaesthetic morbidity and mortality. ERS 2017 guidelines suggest that patients who are high risk of OSA should undergo a sleep study.

Methods: A new pathway was established in December 2022 to ensure patients were screened for OSA and established on treatment pre-surgery. Pre-operative nurses were taught: to complete a STOP-Bang questionnaire, Epworth sleepiness score, and issue multi-night oximetry. Figure 1 demonstrates the flow of the fast-track (green) and the normal pathway via the sleep service (cream).



	Treatment started (*n* =30)	Discharged (*n*= 32)
Age, years (mean, SD)	65 ± 12.6	66 ± 11.3
Body mass index, kg/m2 (mean, SD)	35.0 ± 6.8	33.1 ± 6.4
Male sex, *n* (%)	22 (73)	27 (84)
Epworth sleepiness score (mean, SD)	9.7 ± 5.1	4.2 ± 2.0

Figure 1.

Exclusion criteria: not seen via fast-track; did not return equipment.

Results: Eighty-six patients met criteria for OSA screening, 24 patients excluded, 62 followed the fast-track pathway. Figure 1 shows patient characteristics, pathway and sleep disordered breathing (SDB) severity. Thirty patients (48%) started CPAP therapy. Referral-to-treatment-time (RTT) was 6 days compared to 42 days if a monitor was not issued by the pre-operative team.

The number of patient contacts with the department was also lower with the fast-track pathway compared to the urgent sleep pathway, 2 contacts versus 6 contacts.

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Thirty-two patients were discharged, 13 had no evidence of SDB and a STOP-Bang <5. STOP-Bang was miscalculated 42% of the time, errors occurred on history collection of witnessed apnoeas and measurement of collar size.

Conclusions: There is merit in establishing a pathway of this nature. Clear benefits can be seen on the RTT averages and number of patient contacts.

The STOP-Bang miscalculation has been addressed with the pre-operative nurses, disposable tapes provided for accurate collar size measurement; it is predicted that this will reduce inappropriate referrals. The ODI cut-off will be changed to 3% to comply with newest guidance. Patient satisfaction and compliance post-surgery will also be assessed. These changes will be audited in the next cycle.

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Chambers, T. et al. (2023). Perioperative management of Obstructive Sleep Apnoea: Present themes and future directions. Current Opinion in Pulmonary Medicine, 29(6), 557-566.

P22

A Quality Assurance Review Model for Pulmonary Function – The Royal Papworth Method

Miss Holly Le Winton[1], Miss Lucy Robertson, Mr Joshua Barnes, Mr Karl Sylvester

[1]*Royal Papworth Hospital, Cambridge, United Kingdom*

Introduction: Prior to the COVID-19 pandemic, pulmonary function test (PFT) quality control procedures were undertaken monthly in the Respiratory Physiology department at Royal Papworth Hospital. Due to COVID-19, quality control procedures were temporarily postponed. In June 2022 the department re-introduced quality assurance systems, to re-assess the quality of PFT's (spirometry, gas transfer and static lung volumes), ensuring PFT's were performed in accordance with guidance (Sylvester et al 2020: Graham et al 2017: Graham et al 2019). These statements provided recommendations on quality assurance systems to ensure that pulmonary function testing is as accurate and precise as possible and are reliable for clinical decision-making.

Methods: A monthly quality control programme was developed involving both a senior respiratory physiologist (Band 6 or above) and a respiratory physiologist (Band 5). 20 PFT's were randomly selected from the previous month, with 1-3 PFT's per respiratory physiologist being reviewed. Errors were fed back to individuals with support provided to prevent re-occurrence. Common errors across individuals were addressed anonymously in our weekly department meeting, where there was opportunity for questions and re-training. As part of continuous improvement of the quality control procedures in June 2023, errors were sub-categorised into clinical and non-clinical, to help identify those with the greatest potential to impact on clinical decision-making.

Results: Figure 1a displays the number of errors, while figure 1b shows the clinical and admin errors assessed, figure 1c then shows the trends.

Conclusion: This quality improvement project has highlighted the importance and impact of undertaking regular quality assurance procedures. The procedure has helped demonstrate the department's compliance with

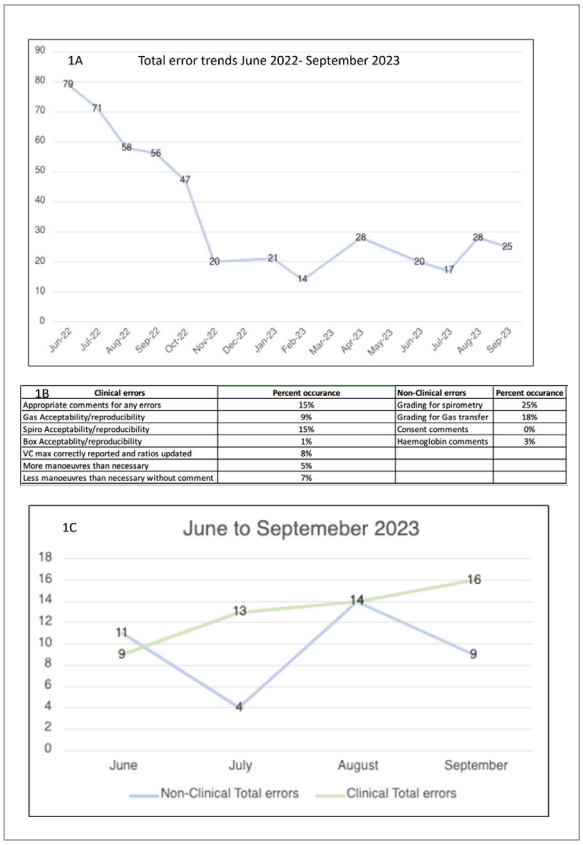

Figure 1.

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national standards, acting as a service improvement tool to highlight areas for further development, aiding staff to meet expected standards, whilst supporting the department's plan of obtaining Improving Quality in Physiological Services (IQIPS) accreditation.

P25

UHNM Respiratory Physiology service improvement initiative: A review of the departmental new clinic structure; how has this benefited the department/service?

Mrs Elizabeth Powell[1], Ms Rachel Heath[1]

[1]University Hospitals of North Midlands, Stoke-on-Trent, United Kingdom

Introduction: Prior to the COVID-19 pandemic, the respiratory physiology clinic structure had been in place since 2012. The service had grown organically to meet the rising service demands; however, this had evolved into a convoluted structure with frequent force bookings and little time for staff enrichment. COVID-19 highlighted that the NHS had to adapt and look at new ways of working. One of the priorities was to revise the department's clinic structure.

Aim: The aim of this audit was to assess the impact and viability of a service improvement initiative which involved an overhaul of the departments working ethos and the implementation of a new clinic structure.

Method: A retrospective service audit was performed on pulmonary function data acquired during routine clinical practice. The timeframe selected was the same 27-week period in 2022/2023. This timeframe was selected to compare the improvement initiative, while reducing the possible impact of seasonal variation. A process capability index (Cpk) was used as a statistical measure of service performance. An arbitrary value of two was assigned to the Cpk, based on previous business models. Values greater than two indicated a robust service with little unnecessary variation.

Results: Prior to the service improvement initiative, the respiratory service showed significant non-centralised variation (Cpk 0.77). The average number of PFTs performed daily was 10.0. Run chart analysis highlighted significant trends around the mean, alluding to an unstable process that was influenced by external factors. In comparison, the new clinic structure demonstrates an improvement in the process's capability (Cpk 1.06) with an increase in the average number of daily tests (11.4 PFTs). Though there is still daily variation, it is now common cause variation. Special cause variation has been eradicated.

Conclusion: This audit has identified that the changes in clinic structure have elicited service improvements, such as creating a surge capacity allowing the department to adequately adapt to external factors without significant adverse impact on daily performance. Additionally, we have increased capacity to meet future demands and provided staff with more time/opportunities for further training/development. Therefore, increasing the department's efficiency and improving staff welfare and workplace enthusiasm.

P27

Occupational asthma due to mild steel?

Mr Samuel Wallbanks[1,3], Dr Kimberley Nettleton[1,3], Mr Christopher Huntley[1,3], Dr Vicky Moore[2,3], Professor Sherwood Burge[3], Mr Gareth Walters[1,3]

[1]Birmingham Heartlands Hospital, Birmingham, United Kingdom, [2]University Hospitals Coventry & Warwickshire, Coventry, United Kingdom, [3]Birmingham Occupational Lung Service, Birmingham, United Kingdom

Introduction: Mild steel is not traditionally thought to represent a cause of sensitisation-induced occupational asthma (OA). Following the inciting case in October 2015, 28 cases from a large heavy machinery manufacturer presented with symptoms consistent with OA in the period from 2015 to 2024. This study documents the initial 16 cases diagnosed with OA at this workplace.

Methods: As part of the OA pathway, new patients have a full occupational history, spirometry with FeNO, chest X-ray and a methacholine challenge test with skin prick and allergy testing. The most sensitive and specific test for OA is serial peak expiratory flow (PEF) measurements performed over 4 weeks, analysed with OASYS; a computational software which analyses work and rest PEF data (1). Data are presented as frequencies and proportions.

Results: Of the 16 cases of OA reported in this analysis, 10 are welders, 1 robot welder, 2 are CNC operators, 1 paint sprayer, 1 short blaster and 1 plasma cutter. 14 of 16 (88%) had spirometry within the "normal range" for their age, sex, ethnicity and height. Three of 16 (14.7%) showed longitudinal declines in FEV1 of >400 mL over 4 years. Of the 9 who had methacholine challenge testing, 4 were

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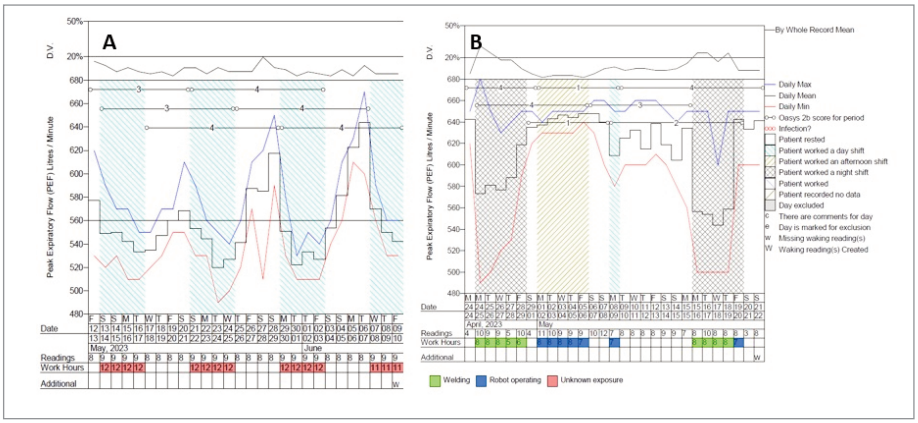

Figure 1. Two cases of OA with delayed (A) and immediate (B) deteriorations in PEF related to work.

reactive (44.4%). All were diagnosed with serial PEFs, with a median OASYS score of 3.43 (2.8-3.8).

Conclusions: The exact cause of OA in this group is unclear. Whilst welding fume appears to be the most likely explanation, the divergence in clinical presentation, types of reaction, and components within the mild steel make it trick to specify the exact cause at present. A workplace challenge test will be performed in collaboration with the workplace to better identify a cause for this outbreak.

Reference

1. Burge et al, (1999). Development of an expert system for the interpretation of serial peak expiratory flow measurements in the diagnosis of occupational asthma. Occupational and environmental medicine, 56(11), 758.

P28

Concordance of COPD diagnosis when comparing NICE criteria with SRs following introduction of GLI predicted equations and new SR indexes?

Mrs Sara Mcarthur[1], Mr Shaun Baxter[1]

[1]*The Royal Infirmary of Edinburgh, NHS Lothian, Edinburgh, Scotland*

Introduction: A previous study determined that 9% of patients attending for reversibility testing via primary care referral had results that would fulfil the GOLD criteria (same categorisation as NICE) for mild COPD but were normal using SRs (McArthur et al, ERJ Sep 2019, 54 (supp 63) PA1115; DOI: 10.1183/13993003.congress-2019.PA1115) (using ECCS predicted equations), which resulted in a ratifying comment being added to primary care reports (Although patient results would fulfil the criteria for mild COPD using NICE guidelines, please note that a ratio <70 is normal for this patient).

With the introduction of new predicted equations (GLI 2012/2017) and SR indexing (Sylvester et al, BMJ Open Respiratory Research 2020;7:e000575. doi: 10.1136/bmjresp-2020-000575) in current commenting practices the effect this has on prevalence and severity of abnormality should be investigated.

Aim: To determine if concordance of COPD diagnosis has changed when comparing NICE criteria with SRs following the introduction of GLI predicted equations and new SR indexing ranges.

Methods: A retrospective analysis of data collected over a 1 year period in patients with suspected COPD were compared with previously collected data, and prevalence of COPD and severity of diagnosis investigated.

Results: See Table 1.

Conclusion: There is greater concordance between NICE and the new SR indexing in patients with suspected COPD primary care referrals after the transition to GLI predicted equation (increase by 4%). However two percent more patients now fulfil the criteria for NICE mild COPD when they are normal based on SRs, therefore the use of the ratifying statement is currently justified.

	Total number of patients included	Normal ventilatory capacity, above predicted (number and percentage)	Post-bronchodilator showing normal SR although fulfils criteria for mild COPD (number and percentage)	Different post-bronchodilator Classification to NICE (number and percentage)	Post-bronchodilator SRs Concur with NICE (number and percentage)
2018/2019	782	126 16%	71 9%	164 21%	421 54%
2022/2023	1094	152 14%	115 11%	188 17%	639 58%
Since change in guidelines (%)		**Decrease 2%**	**Increase 2%**	**Decrease 4%**	**Increase 4%**

Table 1:

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P32

Noisy Breathing during exercise in a Cystic Fibrosis patient - What's the cause?

Colleen Carden[1], Paul Burns[1], Ross Langley[1], Philip Davies[1], David Wynne[1]

[1]Royal Hospital for Children, Glasgow, Scotland

Introduction: A cystic fibrosis (CF) patient with co-existing Crohn's disease had previously had a spell in intensive care and was intubated due to bowel surgery complications. He later presented with exercise intolerance and what the PE teacher described as wheeze on exercise. It had been noted that he had a flattened inspiratory loop on spirometry potentially indicating an upper airway obstruction. There was no expiratory airflow limitation and no response to bronchodilator. A cardio-pulmonary exercise test (CPET) was performed to investigate the cause of the symptoms.

Methods: CPET was performed on a cycle ergometer with an incremental ramp protocol. Following this a continuous laryngoscopy during exercise (CLE) was performed. The patient was treated surgically by ENT using a web excision of posterior laryngeal web. They were followed up for CPET and spirometry post-surgery.

Results: Primary CPET performed showed ventilatory limitation and stridor in keeping with an upper airway obstruction. CLE revealed a laryngeal web. Surgery was performed and CPET showed a normal ventilatory response with no stridor. Ventilatory analysis of the CPET is shown in the table below. Tidal volume and breathing frequency response was improved. The spirometry had a normal inspiratory loop.

Conclusion: This case shows the valuable use of CPET and CLE in the diagnosis of upper airway obstruction when symptoms are only present during exercise. CPET findings were indicative of several abnormalities that indicated an upper airway ventilatory abnormality. The improvements seen in ventilatory responses indicate the successful surgical intervention.

Peak Parameters	Pre	Post	% Change
Ventilation (L/min)	37	79	114
Tidal Volume (L)	1.164	1.250	7
Resp Rate (min^{-1})	32	63	97
$ETCO_2$ (kPa)	5.90	3.98	-33
$VeVCO_2$ slope	22.1	27.0	26

P33

Deriving the optimal VO2atAT/PredPeakVO2 threshold for predicting low Peak VO2

Dr Ben Knox-Brown[1], Mr Chris Harding[2], Dr Karl Sylvester[1]

[1]Respiratory Physiology, Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]Respiratory Physiology, Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

Introduction: A VO_2 at anaerobic threshold as a percentage of peak predicted VO_2 (VO_2atAT/PredPeakVO_2) less than 40% has been considered an indicator of disease, despite little evidence. We aimed to determine the optimal threshold for VO_2atAT/PredPeakVO_2 which can predict a low peak VO_2, using data from cardiopulmonary exercise tests (CPET).

Methods: Data was retrospectively collected from patients referred to Cambridge University Hospitals NHS FT for CPET between 2016 and 2021. Data was included if the CPET was physiologically maximal. Multivariable logistic regression was used to investigate the association between VO_2atAT/PredPeakVO_2 and low peak VO_2 defined as a peak $VO2_2$ less than the lower limit of normal (LLN). We adjusted for age, sex, BMI, referral reason, and smoking history. Post-estimation commands were used to generate the Youden index, representing the VO_2atAT/PredPeakVO_2 threshold with the highest sensitivity and specificity for predicting low Peak VO_2. We then used linear regression to assess the association of the new threshold with CPET parameters.

Results: Data from 217 patients were included. Mean age was 51 years (±15.6), with 51% being female. Mean BMI was 28.3 (±5.7). 63% were referred for shortness of breath of unknown cause. Mean Peak VO_2 was 2.1L/min (±0.7) with 24% having a low Peak VO_2. The results of the regression analysis showed that for a 1% increment in VO_2atAT/PredPeakVO_2, odds of having a low Peak VO_2 decreased by approximately 14% (OR: 0.86, 95%CI 0.81-0.91, p<0.0001). The optimal VO_2atAT/PredPeakVO_2 threshold for predicting a low Peak VO_2 was 44%, with a sensitivity of 83.3%, specificity of 84.7%, area under the receiver operating curve of 0.88, and a Youden index of 0.68. 20% of patients were below the 44% threshold, which was associated with having a significantly lower Peak VO_2 (β: -0.48L/min, 95%CI -0.64, -0.31, p<0.0001), oxygen pulse (β: -2.51ml/beat, 95%CI -3.50, -1.54, p<0.0001), and steeper cardiovascular slope (β: 10.07, 95%CI 5.10-15.04, p<0.0001).

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Conclusion: A VO_2atAT/PredPeakVO_2 less than 44% has the highest sensitivity and specificity for predicting a low Peak VO_2 and is associated with an impaired cardiovascular response to exercise. Further validation of this threshold is required in a range of different patient

P34

Is the oxygen uptake efficiency slope (OUES) a good surrogate for VO2 peak in patients with unexplained breathlessness?

Mr Chris Harding[1], Dr Chara Alexiou[1], Dr Ben Knox-Brown[2], Dr Karl Sylvester[1,2]
[1]Cambridge University Hospitals NHS Trust, Cambridge, United Kingdom, [2]Royal Papworth Hospital NHS Trust, Cambridge, United Kingdom

Introduction: Evidence (Akkerman M et al, Pediatric Exercise Science, 22(3)2010 & Gavotto A et al, Archives of Disease in Childhood,2020) suggests that the oxygen uptake efficiency slope(OUES) could be used as a surrogate for VO2 peak in the presence of a sub-maximal test. We, therefore, wished to determine the relationship between OUES and peak VO2 to confirm this claim.

Method: OUES and VO2 peak values were compared in 227 physiologically maximal tests performed to ARTP standards (Pritchard A et al, BMJ Open Respiratory Research, 2021) over 2022/2023. Patients were sub-classified by BMI and breathing pattern response for comparisons across subject groups. We also compared how many patients were classified as having normal aerobic capacity using both values.

Results: Median (IQR) values demonstrate significant difference between OUES 1719 (1373-2191) and VO2 peak 1635(1247-2121) in all patients when assessed by Wilcoxon

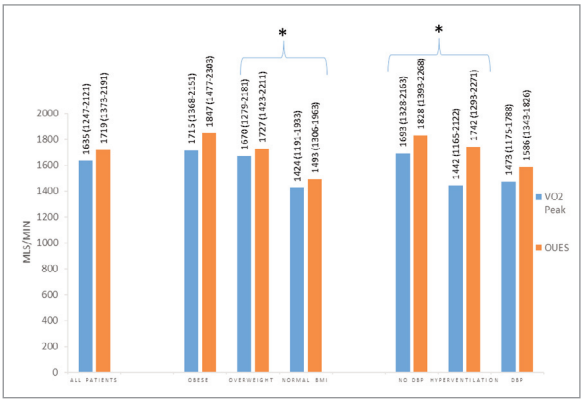

Figure 1. Comparison of Media (IQR) VO2 peak and OUES in all patients and then restricted analysis of each sub-group.
*No significant difference observed p<0.001

Signed-rank test p<0.001. When sub-categorised, analysis that was restricted to those that had a BMI classified as obese and then those with a dysfunctional breathing pattern also had significantly different OUES ((1847(1477-2303) and 1586(1343-1826)) and VO2 peak ((1715(1368-2151) and 1473 (1175-1788)) p>0.01. There was no significant difference between median(IQR) OUES and VO2 peak when analysis was restricted to those with no breathing pattern disorder ((1828(1393-2268) and 1693(1328-2163), hyperventilation ((1742(1293-2271) and 1442(1165-2122), normal BMI((1493(1306-1963) and 1424(1191-1933)) and overweight ((1727(1423-2211) and 1670(1279-2181)) p< 0.001. The underweight sub-category could not be analysed due to its small sample size. When compared to the measured peak VO2, 179 of 227 patients (79%) were correctly classified as normal or abnormal by OUES, with a positive predictive value (PPV) of 82% and a negative predictive value (NPV) of 86%.

Conclusions: OUES could be used to estimate VO2 peak in sub-maximal CPETS in the majority of patients reporting unexplained breathlessness. However, in obese patients with a BMI > 30kg/m2 and in those with a dysfunctional breathing pattern, OUES compared to VO2 peak suggested significant differences. OUES also provided a good positive and negative predicted value for normal or abnormal aerobic capacity. This could be particularly useful in providing a more accurate calculation of aerobic capacity and functional limitation during CPETS in the clinical setting.

P35

Evaluation of a physiologist-led paediatric home spirometry assessment

Ms Emma Raywood[1], Ms Megan Robshaw[1], Ms Cara Oliver[1], Mrs Helen Parrott[1]
[1]Nuvoair Clinical Team, United Kingdom

Introduction: Spirometry is required for diagnosis and can provide evidence for treatment optimisation in asthma. The feasibility and validity of home spirometry is unclear with recent data, in adults with asthma, demonstrating poor engagement and data quality (Williams, 2023, ERJ Open Research). Home spirometry may be even more challenging in children.

The aim of this analysis was to assess the feasibility and effectiveness of the NuvoAir paediatric home spirometry asthma assessment.

Methods: Children and young people aged 5 to 17 years referred to specialist teams (primary, secondary and

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tertiary care) with confirmed or suspected asthma were also offered the NuvoAir 4-12 week physiologist-led home spirometry assessment.

Patients or their parents installed the NuvoAir Home app on their own devices and were given spirometry coaching with a physiologist via videocall. Patients used an Air Next Bluetooth spirometer to record regular spirometry (frequency personalised, mean 4 days a week) and when symptomatic. A report was produced at the end of the assessment period with results and recommendations.

Results: Data is presented from the first 30 children referred for the home spirometry assessment, 37% were spirometry naïve. The main reason for referral was either an unclear diagnosis of asthma (12) or for treatment optimisation (18). Patients were aged mean (SD) 10.2y (3.6y), 13 were female 17 male.

The median adherence to the home spirometry personalised protocol was 61% (IQR 35 to 101%). In total 553 spirometry tests were recorded (mean 20 per patient), with 60% good quality tests (computer interpretation A-C, ATS/ERS 2005). Overreading identified a higher proportion where data was usable using ATS/ERS 2019 interpretation, reanalysis is planned. Reports were provided inclusive of serial spirometry to support diagnosis and/or treatment decisions in all 30 patients.

Conclusions: The home spirometry assessment was feasible and provided good quality data and engagement to support diagnosis and treatment optimisation. Further analysis is planned to determine the impact on speed, accuracy and respiratory diagnosis outcomes

In contrast to other studies, this cohort received personalised coaching and carried out multiple consecutive tests (including when symptomatic) which enabled the capture of rich data insights for diagnosis and treatment optimisation.

P36

The association between socioeconomic status and asthma diagnosis in children and young people referred to the Leicester asthma diagnostic pathway

Miss Natalie Blyth[1], Mr Joe Madge[1], Ms Gemma Vissani[1], Ms Charlotte Simpson[1], Mr Prakash Patel[1], Dr Vinyak Rai[1], Dr David Lo[2], Dr Molla Imaduddin Ahmed[1], Dr Erol Gaillard[2]

[1]University Hospitals of Leicester, Leicester, United Kingdom, [2]University of Leicester, Leicester, United Kingdom

Introduction: Symptoms of asthma in children and young people (CYP) include a wheeze, cough and breathlessness. However, symptoms are often non-specific and objective tests are recommended to confirm the diagnosis from age 5 (NICE, 2017).

Socioeconomic deprivation is associated with poor outcomes in asthma. Factors such as air pollution and second-hand smoke may play an important role (Alsallakh et al., 2021). However, it is unclear how socioeconomic status and likelihood of confirming an asthma diagnosis in CYP referred for objective testing is associated.

Aims: To evaluate the association between socioeconomic status and confirmed asthma diagnosis in CYP referred by the GP for diagnostic testing.

Method: GP practices referred 5–18 year-olds with suspected asthma to the Leicester paediatric community asthma diagnostic pathway (LPAP). Where 1st line tests (spirometry, BDR and FeNO) were inconclusive, patients progressed to second line bronchoprovocation challenge tests (treadmill and/or provocholine challenge test) as per the LPAP. Data was analysed to assess outcomes in relation to the patient's socioeconomic status. Socioeconomic status was determined by the patient's postcode using the Index of Multiple Deprivation Decile (IMD10) (1 = most deprived, 10 = least deprived decile) (Ministry of Housing, Communities and Local Government, 2019).

Results: 88 CYP successfully completed the diagnostic pathway. Patients were categorised by IMD10 and LPAP testing outcome (Table 1). 55 CYP had asthma confirmed based on test results. The median IMD10 of those who had asthma confirmed was 3 (IQR 4); the median IMD10 for those where asthma was not confirmed was 7 (IQR 4). Overall, 74% of children from more deprived backgrounds could have asthma confirmed compared with only 49% of children from less deprived backgrounds (chi2 test, p = 0.0172).

IMD Deciles Grouped	Tests Positive (Asthma Confirmed) *N (%)*	Tests Inconclusive (Asthma not Confirmed) *N (%)*
1-to-5	36 (73.5)	13 (26.5)
6-to-10	19 (48.8)	20 (51.2)

Table 1: LPAP outcomes stratified by IMD10

Conclusion: A greater proportion of CYP from more deprived socioeconomic backgrounds referred to LPAP had objective evidence to confirm asthma compared with children from more affluent backgrounds. The reasons for this finding merit further exploration. Hypotheses to be tested are that the referral threshold for testing may be

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higher in children from more deprived backgrounds, more affluent families may present children with symptoms to the GP earlier and/or referral thresholds may be lower.

P37

Post COVID Persistent Exercise Induced Dyspnoea in Children and Young People: is CPET the key test?

Miss Charlotte Richardson[1], Miss Natalie Orr[1], Dr Ioannis Makariou[1], Dr Terry Y Segal[2], Dr Samantha Sonnappa[1]

[1]Royal Brompton Hospital, London, United Kingdom, [2]University College Hospital (UCH), London, United Kingdom

Introduction: There is a limited understanding about post COVID dyspnoea in children and young people (CYP) although breathing pattern disorders have been identified as a cause of post COVID dyspnoea in adults (Frésard et al. BMJ Open Respiratory Research 2022; Mar 9(1)). Reduced pulmonary function has been noted in adults following SARS-CoV-2 infection (Sanchez-Ramirez et al. Biomedicines 2021 9(8)). We aimed to determine the cause of post COVID persist dyspnoea in CYP through pulmonary function testing and cardiopulmonary exercise testing (CPET).

Methods: Data was retrospectively analysed on CYP with post COVID syndrome referred for respiratory workup at Royal Brompton Hospital with post COVID dyspnoea, all had mild COVID-19 infection and not hospitalised with acute infection. Pulmonary function tests (pre and post exercise spirometry, lung volumes, gas transfer) and CPET were performed.

Results: Data is presented from 41 CYP referred for evaluation of persistent post COVID dyspnoea. 32 of 41 (78%) completed a maximal effort CPET. Among these, 15 (47%) exhibited a normal peak oxygen consumption (VO2max), while 17 (56%) showed a reduced VO2max, primarily due to physical deconditioning. Plethysmographic lung volume and transfer factor for carbon monoxide (TLCO) measurements were measured in 25 and 28 out of 41 CYP respectively. All CYP were noted to have normal gas transfers and breathing pattern disorders as identified on CPET. Almost half (19/41) CYP exhibited erratic tidal volume (VT) and breathing frequency (BF), while 13 almost a third (13/41) displayed high and erratic VT above physiological capacity.

Conclusions: The CPET results demonstrate that in CYP experiencing post COVID persistent dyspnoea there was no underlying pulmonary abnormality as demonstrated by there being no cardiac or pulmonary limitation to exercise and normal gas transfer (also indirectly noted on CPET). All patients were noted to have a breathing pattern disorder, which is likely to be the main cause of post COVID persistent dyspnoea in CYP. CPET provided the most useful information in elucidating the cause of post COVID persistent dyspnoea in CYP.

Demographics		Lung Function	
Sex, male: female	14:27	FEV_1 (% pred)	91.6 (89-102)
Height (cm)	166 (162.3-173.1)	FVC (% pred)	90.5 (86-102.7)
Weight (kg)	56.9 (47-67.3)	TLCO (%)	89.1 (81.5-100.4)
BMI (kg/m²)	19.7 (17.8-23)	RV (%)	138.8 (111.2-176.1)
Weight: under/normal/over	6/28/5/2	TLC (%)	101.5 (91.9-105.9)
Hospitalised	0	RV/TLC (% pred)	135 (115.3-172.9)
Age at CPET	16 (14-17)	Post exercise bronchoconstriction	1
CPET Parameters			
VO_{2max} (ml/min/kg)	34.8 (28-42.3)	Peak Heart rate (bpm)	187 (174.5-193)
VO_{2max} (% pred)	82 (65-98)	Peak Heart rate (% pred)	98 (90.5-102.5)
Workload (Watts)	190 (147.5-227.5)	Peak O_2 pulse (% pred)	83 (68-101)
Anaerobic threshold (% of predicted VO_{2max})	64.5 (53.3-77.9)	VE/VCO_2 Slope	29.2 (26-33.3)
Ventilatory reserve (100-VEpeak%)	35 (27-48.5)	$P_{et}CO_2$ Rest (kPa)	4.2 (4-4.4)
Peak breathing frequency (bpm)	45 (38-54)	$P_{et}CO_2$ Peak (kPa)	4.9 (4.6-5.3)
Peak breathing frequency (%pred)	101 (85-122.5)	$P_{et}CO_2$ Recovery (kPa)	4.9 (4.6-5.3)
Breathing Pattern Disorder	41 (100%)	Hyperventilation (PCO_2 <4.2 kPa)	8/41 (19.5%)
		Anticipatory Hyperventilation	20/41 (48.8%)
Type of Breathing Pattern:			
Erratic VT and BF	19/41	Stunted BF (± high/erratic VT)	7/41
High erratic VT and erratic BF	13/41	Stunted VT and high erratic BF	2/41

BMI: body mass index; FEV_1: forced expiratory volume in 1 s; FVC: forced vital capacity; TLCO: transfer capacity for carbon monoxide; RV: residual volume; TLC: total lung capacity; VO_{2max}: maximal oxygen uptake; VE: minute ventilation; VT: tidal volume; BF: breathing frequency

Table 1: Demographic, CPET, lung function and breathing pattern characteristics of children with post COVID syndrome. Data are shown as number (%) or median (IQR)

P38

Determining the inter-rater agreement of the VO2 at AT between CPET practitioners within a large tertiary CPET service

Mr Jason Burge[1]

[1]University Hospital Coventry and Warwickshire NHS Trust (UHCW), CV22DX, United Kingdom

Introduction: Cardiopulmonary exercise testing (CPET) measures the oxygen uptake at the anaerobic threshold (VO2 at AT) to predict post-operative complications including mortality, morbidity, and length of stay (LOS). VO2 at AT is determined using the gold standard v-slope methodology (Beaver et al. J. Appl. Physiol 1986: 60(6); 2020-2027) and dual methods criteria (Cooper and Storer et al. J Sports Sci Med 2017: 16(3); 396-406). There is subjective interpretation of the angle of deflection

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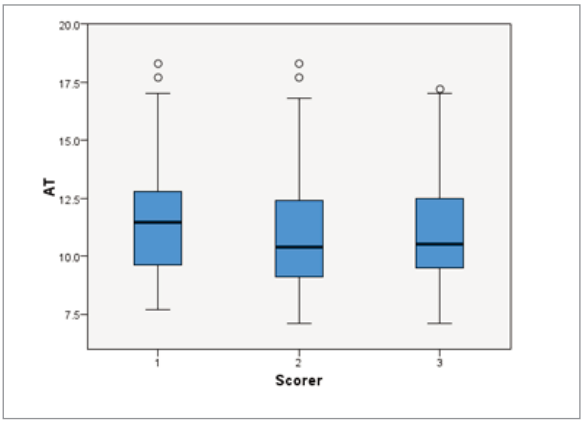
between S1 and S2 slopes (Abbott et al. British journal of anaesthesia 2018: 120(3); 475-483) and therefore ensuring a high degree of inter-rater agreement is essential.

Methods: AT data was collected from 30 consecutive patients who performed pre-operative CPET. VO2 at AT (mL/kg/min) was measured using the v-slope methodology followed by the dual criteria method. CPET practitioners were blinded to the AT which was measured as part of clinical practice. CPET practitioner experience was estimated to range between 500 – 1500 tests performed. Data was analysed using SPSS. An evidenced based VO2 at AT of 11.0 mL/kg/min was used to discern between low (<11.0) and high surgical risk (≥11.0) patients. Intraclass correlation coefficient (ICC) and Fleiss's kappa (k) were used to assess inter-rater variability.

Results: Results demonstrated all 3 practitioners agreed that an AT was detected (100%). Intraclass correlation for 'single' VO2 at AT measures were ICC = 0.867 (95% CI, 0.770 – 0.930) demonstrating 'good' inter-rater agreement. Intraclass correlation for 'average' VO2 at AT measures were ICC = 0.952 (95% CI, 0.910 – 0.976) demonstrating 'excellent' inter-rater agreement. Fleiss's kappa demonstrated a 'good' strength of agreement between CPET practitioners k = .686 (95% CI, 0.480 – 0.893).



Conclusions: Our study suggests a good level of inter-rater agreement between CPET practitioners within a large tertiary CPET service when scoring VO2 at AT. This study highlights the importance of performing robust quality assurance processes within diagnostic exercise services to ensure consistent high-quality and clinically reproducible results which may impact upon surgical stratification for patient's clinical care.

P39

Abnormal oxygen pulse response in paediatric cystic fibrosis cardiopulmonary exercise tests - an update.

Colleen Carden[1], Paul Burns[1], Rebecca Lennon[1], Ross Langley[1], Philip Davies[1]

[1]*Royal Hospital for Children, Glasgow, Scotland*

Introduction: Children with Cystic Fibrosis (CF) undergo annual cardiopulmonary exercise testing (CPET) as part of their routine assessment. It had previously been reported that several were showing an abnormal oxygen pulse response (O2pulse) with a flattening and/or fall at higher intensity exercise. Our primary aim was to look at follow up CPETs to evaluate for the repeatability of an abnormal O2pulse. Our secondary aim was to look at a subset of patients who had CPETs pre and post initiation of Kaftrio and evaluate the O2pulse response.

Methods: This was a retrospective analysis of clinical data obtained over a 3 year period. Spirometry and CPET using an incremental maximal ramp protocol on a cycle ergometer were performed. A paired sample student T-Test was used to look for a significant difference pre and post Kaftrio treatment.

Results: There were 32 patients who had sequential CPET measurements. 21 had a normal initial O2pulse response and 11 were abnormal. On subsequent CPET, 17 of the patients with normal baseline O2pulse responses, remained normal and 4 became abnormal. Of the 11 with an abnormal initial response, 9 normalised on subsequent testing.

10 patients had CPET pre and post Kaftrio. 7 had an abnormal baseline O2pulse response. Of these, 2 showed a normal response on CPET post Kaftrio. The 3 that had a normal baseline all showed an abnormal response post Kaftrio. There was no significant difference in any CPET parameters pre and post Kaftrio. There was a significant difference in the FEV1 and FEV1/FVC z-score. Data is shown in the table below.

Conclusions: We have shown that the oxygen pulse response in children with CF is not repeatable and abnormal response can change to normal the following year and vice versa. The use of triple modulator therapy does not seem to have any impact on the O2pulse response or aerobic capacity. It does however significantly improve FEV1. This research casts doubt on the significance of an abnormal O2pulse response in children with CF and further work is required to determine

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Parameter	Pre Kaftrio Mean	95% CI	Post Kaftrio Mean	95% CI	P Value
Sex (M/F)	6/4	-	-	-	-
Age	10.5	9.4, 11.5	11.9	10.8, 13.0	-
Height z	0.06	-0.30, 0.41	0.07	-0.14, 0.27	0.48
Weight z	0.51	0.06, 0.96	0.48	0.04, 0.91	0.43
BMI z	0.63	0.12, 1.14	0.53	-0.12, 1.18	0.31
FEV_1 z	0.03	-0.86, 0.92	0.47	-0.57, 1.51	0.04
FEV_1/FVC z	-0.47	-1.07, 0.14	0.12	-0.67, 0.91	0.01
VO_2peak % predicted	88.1	83, 93	87.9	78, 98	0.48
VO_2 peak ml/kg	36.1	33.0, 39.3	36.1	31.1, 41.2	0.5
O2 pulse % predicted	93	87, 99	89	80, 99	0.24
Peak Heart Rate (HR)	190	187, 193	188	184, 192	0.2
Ventilatory threshold (% predicted VO2peak)	52	45, 60	48	40, 57	0.11

the cause of this and the variability seen in repeated measures.

P40

A SIMPLE METHOD FOR CHECKING THAT LUNG FUNCTION TEST RESULTS ARE QUALITY ASSURED CORRECTLY AND CONSISTENTLY BETWEEN RESPIRATORY PHYSIOLOGISTS

Dr Harpal Kalsi[1], Ms Janina Mallari[2], Dr Hajar Hajmohammadi[1], Dr James Scales[1], Dr Ivelina Tsocheva[3], Ms Jasmine Chavda[3], Dr Rosamund Dove[1], Dr Helen Wood[1], Dr Ian Mudway[4], Ms Grainne Colligan[1], Mr Luke Sartori[1], Mr Jason Le[1], Ms Jessica Mitchell[1], Ms Jessica Moon[1], Professor Gurch Randhawa[3], Professor Chris Griffiths[1]

[1]Queen Mary University of London, London, United Kingdom, [2]Barts Health NHS Trust, London, United Kingdom, [3]University of Bedfordshire , Luton, United Kingdom, [4]Imperial College London, London, United Kingdom

Introduction: The quality assuring (checking) of lung function test results is a mandatory step performed by Respiratory Physiologists (RPs) to ensure confidence in accepting/rejecting results. The cross-checking of quality assured (QA) results between individuals reinforces confidence in results to be used clinically and for research. The process can also facilitate learning and competency in individuals less experienced or new to testing/ results interpretation. Using spirometry, we describe a simple methodological approach to measure the inter-rater reliability between RP's checking results.

Methods: Test results collected during 3 annual health assessments of children taking part in the CHILL (Children's Health in London and Luton) study were used. 458 (6%) of 7654 results were randomly selected for QA. The level of agreement between 2 RPs was determined using inter-rater reliability and calculation of Cohen's K coefficient. This was for 2 primary parameters, FEV1 (forced expiratory volume) and FVC (forced vital capacity) and for 2 rounds of testing (baseline and post-bronchodilator). Both RPs documented their findings for analysis.

Results: Cohen's K showed moderate to excellent agreement between RPs for baseline and post-bronchodilator FEV1 and FVC. The Cohen's K (and 95% confidence intervals) for baseline FEV1 in years 1, 2 and 3 were 0.817 (0.755 – 0.865), 0.645 (0.541 – 0.73), and 0.848 (0.796 – 0.887). The Cohen's K (and 95% confidence intervals) for post-bronchodilator FEV1 in years 1, 2 and 3 were 0.783 (0.683 – 0.849), 0.647 (0.542 – 0.731), and 0.902 (0.868 – 0.928). The Cohen's K (and 95% confidence intervals) for baseline FVC in years 1, 2 and 3 were 0.73 (0.643 – 0.798), 0.523 (0.396 – 0.631), and 0.745 (0.664 - 0.809). The Cohen's K (and 95% confidence intervals) for post-bronchodilator FVC in years 1, 2 and 3 were 0.77 (0.664 – 0.841), 0.664 (0.564 – 0.746), and 0.88 (0.837 – 0.911).

Conclusions: This very simple methodological approach showed consistency between both RPs findings and showed that they QA data correctly i.e. agreed in their rejection/ acceptance of FEV1 and FVC. This approach could be applied across routine lung function test results when a comparison between RPs findings is warranted.

P41

THE RISKS OF APPLYING NORMATIVE VALUES IN PAEDIATRIC CARDIOPULMONARY EXERCISE TESTING: A CASE REPORT

Mrs Jessica Waterfall[1], Mrs Dawn Shackell[2], Dr Joanna Pepke-Zaba[3], Mrs Katrina Oates[1], Dr Karl Sylvester[4]

[1]Respiratory Physiology Department, Royal Papworth Hospital NHSFT, Cambridge, United Kingdom, [2]Respiratory Physiology Department, Norfolk & Norwich University Hospital NHSFT, Norwich, United Kingdom, [3]Pulmonary Vascular Disease Unit, Royal Papworth Hospital NHSFT, Cambridge, United Kingdom, [4]Lung Function Unit, Cambridge University Hospitals NHSFT, Cambridge, United Kingdom

We present a clinical case in a paediatric subject, that highlights an important issue surrounding the limitations of normative reference values (NRV) for the interpretation of cardiopulmonary exercise testing (CPET). At present, there is no single NRV available that encompasses both adult,

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CPET Variables	Local Hospital (Dec 2018)			Specialist Centre (Dec 2019)		
	Results (absolute)	Bongers 8-18yrs (2014) %predicted	Cooper 6-17yrs (1984) %predicted	Results (absolute)	Bongers 8-18yrs (2014) %predicted	Cooper 6-17yrs (1984) %predicted
Load (W)	89	42%	62%	98	46%	71%
V_{O2peak} (ml.min)	1391	55%	70%	1393	55%	73%
V_{O2peak} (ml.min.kg)	23.5	56%	70%	24.5	59%	73%
V_{O2} @ AT (ml.min)	879			788		
O2 Pulse (ml)	8.9	68%	96%	8.1	62%	90%
V_E/V_{CO2} Slope	45			52		
V_EEq_{CO2} at	44			42		
Lowest oxygen saturation (%)	85			88		
Cardiovascular slope	Normal			Normal		
		Ratio (%)			Ratio (%)	
AT % pred V_{O2max}		35%	44%		31%	41%

V_{O2peak}, peak oxygen consumption; V_{O2} @ AT, oxygen consumption at anaerobic capacity; V_EEq_{CO2} at AT, ventilatory equivalents for carbon dioxide at anaerobic threshold; AT % pred V_{O2max}, anaerobic capacity as a percent of maximal predicted oxygen consumption.

Table 1: Results for CPET parameters with two different NRV applied

paediatric and adolescent populations. As a result of this case, there is an ongoing ERS task force for developing Global Lung Function Initiative reference equations for CPET.

A fourteen-year-old female was initially referred to a local Hospital for investigation of exertional breathlessness and chest pain, initial investigations included a CPET. Following a review, she was diagnosed with a sub-acute/chronic right main pulmonary artery thromboembolism. She was deemed technically suitable for pulmonary endarterectomy surgery but the risks of the operation outweighed the benefits and anticoagulation therapy was continued.

Six months later she was referred to a specialist pulmonary hypertension centre with worsening breathlessness. On review, several non-invasive tests were carried out including a second CPET. The results were interpreted using Bongers et al. 2014 NRV and demonstrated a moderately reduced aerobic capacity with an anaerobic threshold consistent with a diseased status. These were in contrast to the initial CPET which was interpreted using Cooper et al. 1984 NRV. These results suggested only a mild reduction in aerobic capacity with an anaerobic threshold suggestive of a deconditioned subject (see table).

Further interrogation showed that absolute values of CPET parameters were comparable for each set of results, with the 9-panel plot demonstrating abnormal gas exchange for both. It was therefore apparent that the perceived change in functional status between CPETs was due to a difference in NRV applied, rather than as a consequence of a physiological deterioration. Subsequently, the patient underwent a right heart catheterization and MRI. This confirmed the diagnosis of chronic thromboembolic pulmonary hypertension and she was deemed suitable for surgical management.

In summary this case has highlighted NRV are not standardised, and therefore, this may lead to a significant difference in result interpretation between different medical institutions. Second, inadequate NRV impact on differential diagnosis, risk stratification and appropriateness for surgical and invasive intervention.

P42

Respiratory Physiologist' Role in reducing the risk of acute deterioration in Paediatric Patients

Daniel Woodcock[1], DR Meredith Robertson

[1]Evelina London Children's Hospital, Guy's & St Thomas' NHS Foundation Trust, London, United Kingdom

Introduction: A clinical incident report, Datix, was submitted in 2021 where a patient with very abnormal spirometry was not reviewed for several months by the requesting clinician.

In January 2022 The Evelina Paediatric Respiratory Service introduced home spirometry monitoring.

The realisation that patients with objective evidence of deterioration may not be picked up in a timely manner led to the creation of an escalation policy which was applied to all patients who attended for respiratory assessment or sent results from home monitors.

Criteria for Escalation: For symptomatic patients or asymptomatic patients who do not appear unwell but their physiological parameters indicate significant deterioration or risk:

- % predicted FEV1 reduced by 20% from previous best result
- Bronchodilator reversibility of 25% or more in FEV1

Escalation pathway: Patient appointment with requesting clinician same day: Attempt to call clinician, email if unable to contact.

Patient without a same day appointment with the requesting clinician: bleep clinical to assess the patient in the Physiology department.

Methods: The policy was established after stakeholder consultation and a standard operating procedure (SOP) was distributed and relevant parties were made aware. An escalation log book was created to track the number of

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Number of Patients	BDR %	Steroids	Await OPA review	ED review	Adherence addressed	Step-up ICS
7	25-30	1	5		1	
18	30-40	5	10	1	2	
4	>40	1	1		1 (smartinhaler)	1

Table 1: Summary of escalation events related to high bronchodilator reversibility between 19.04.22 - 30.03.23

escalations made. The SOP was continually reviewed and changes to policy made, according to Plan-Do-Study-Act (PDSA) methodology.

44 events were recorded in the first year of the escalation policy, 10 related to home spirometry, five symptomatic patients and 29 due to high bronchodilator reversibility.

After a review of the results in table 1 the SOP was updated to no longer trigger escalation for patients with BDR of 25-30% as these were felt to be lower risk.

Conclusion: Our results indicate that an escalation policy is helpful for identifying patients who are at risk of having a sudden asthma attack or impending infective exacerbation of suppurative lung disease.

This study shows an escalation policy can improve patient safety and outcomes, especially in cases where the testing session and doctor consultation are not on the same day.

P43

Rectal ointment for your aCBG appointment: gunpowder, good reason, no clot

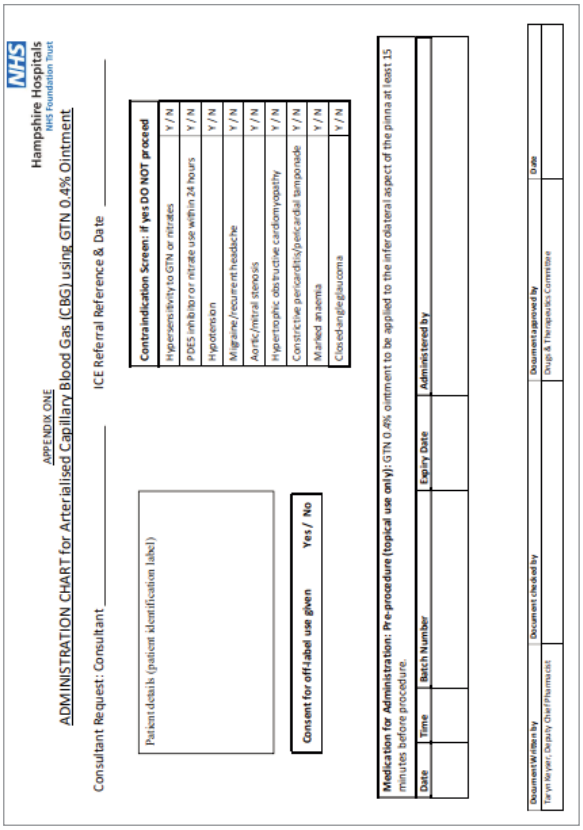
Dr Harry Griffin[1], Dr Lee Dexter[2], Dr Michael Hughes[1], Miss Madison Geeves[1]

[1]Respiratory Physiology and Sleep Department, Hampshire Hospitals NHS Foundation Trust, UK, Basingstoke, United Kingdom, [2]Respiratory Medicine Department, Hampshire Hospitals NHS Foundation Trust, UK, Basingstoke, United Kingdom

Introduction: An arterialised Capillary Blood Gas (aCBG), normally performed on the earlobe using a lancet or scalpel, is a minimally invasive alternative to an Arterial Blood Gas (ABG). However, its accuracy in assessing the true partial pressure of arterial O_2 and CO_2 (PaO_2 and $PaCO_2$) is heavily reliant on the 'arterialisation' of the earlobe capillaries. Prior to discontinuation, Transvasin cream and a hot water filled glove was used by Hampshire Hospitals NHS Trust. Subsequently, two alternative Rubefacient creams were trialled with only mixed success (RadianB and Deep Heat). Glycerol Trinitrate (GTN) ointment for aCBGs has previously been reported in the intensive care setting (Vaquer et al. AIC, 2014). Utilisation in an outpatient setting was discussed with the Drugs and Therapeutics Committee (DTC).

Methods: Due to the small theoretical risk of hypotension, a six-month trial was approved by the DTC, subject to: 1) provision of a trust wide aCBG SOP, specific to GTN use; 2) addition of a Patient Specific Directive on the eReferral; 3) compulsory administration chart, with contraindications and recorded consent for off-label use (Figure 1) and; 4) reporting Adverse Drug Reactions (ADR) via the Trusts incident reporting system.

Results: Referrals for aCBGs with GTN ointment and hot water filled glove commenced on the 01.10.2023 with a total of 28 successful tests performed to date (23.01.2024). An additional two patients were contraindicated for GTN use (chronic migraines and hypotension). One ADR was recorded, whereby the patient felt faint immediately upon firing of the lancet and was then shown to be hypotensive. It is unknown if the



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GTN or anxiety related to the blood sampling resulted in the symptoms and hypotension. Anecdotally, most physiologists using GTN ointment reported a higher success rate in achieving a subjectively perceived 'fast flowing' sample vs. the previously used Deep Heat cream.

Conclusions: Anecdotally, GTN ointment appears to be an effective vasodilator for aCBG. Continued monitoring should better identify the relative risk of side effects. Future research comparing the sampling success rate, the pO_2 and pCO_2 obtained from aCBGs using GTN ointment vs Rubefacient creams and a true ABG, would help evaluate its efficacy.

P44

An unusual physiological response to exercise in an adult Fontan patient – A case study

Mr Joshua Barnes[1], Miss Kate Donovan[1], Dr Victoria Stoll[1], Dr Karl Sylvester[1,2]

[1]Royal Papworth Hospital NHS Foundation Trust, [2]Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

Introduction: A cardiopulmonary exercise test (CPET) provides an objective assessment of exercise tolerance and provides prognostic information in patients who have undergone a Fontan procedure.

A 24-year-old male (BMI: 21kg/m2) was referred for a CPET to assess his exercise capacity. His congenital cardiac diagnosis consisted of complex right atrial isomerism with a hypoplastic left-ventricle, double-outlet right ventricle, atrioventricular septal defect and severe aortic valve regurgitation. Fontan circuit completion was undertaken by age 12 resulting in a total cavopulmonary connection. Ongoing symptoms included occasional breathlessness and infrequent palpitations.

Methods: The patient underwent a CPET on a cycle ergometer to volitional exhaustion in accordance with the Association for Respiratory Technology and Physiology (ARTP) 2021 CPET guidelines (Pritchard et al., 2021). Wasserman et al., (2005) CPET predictive values were utilised.

Results: The test was deemed sub-maximal in accordance with ARTP CPET guidelines, however, the heart rate

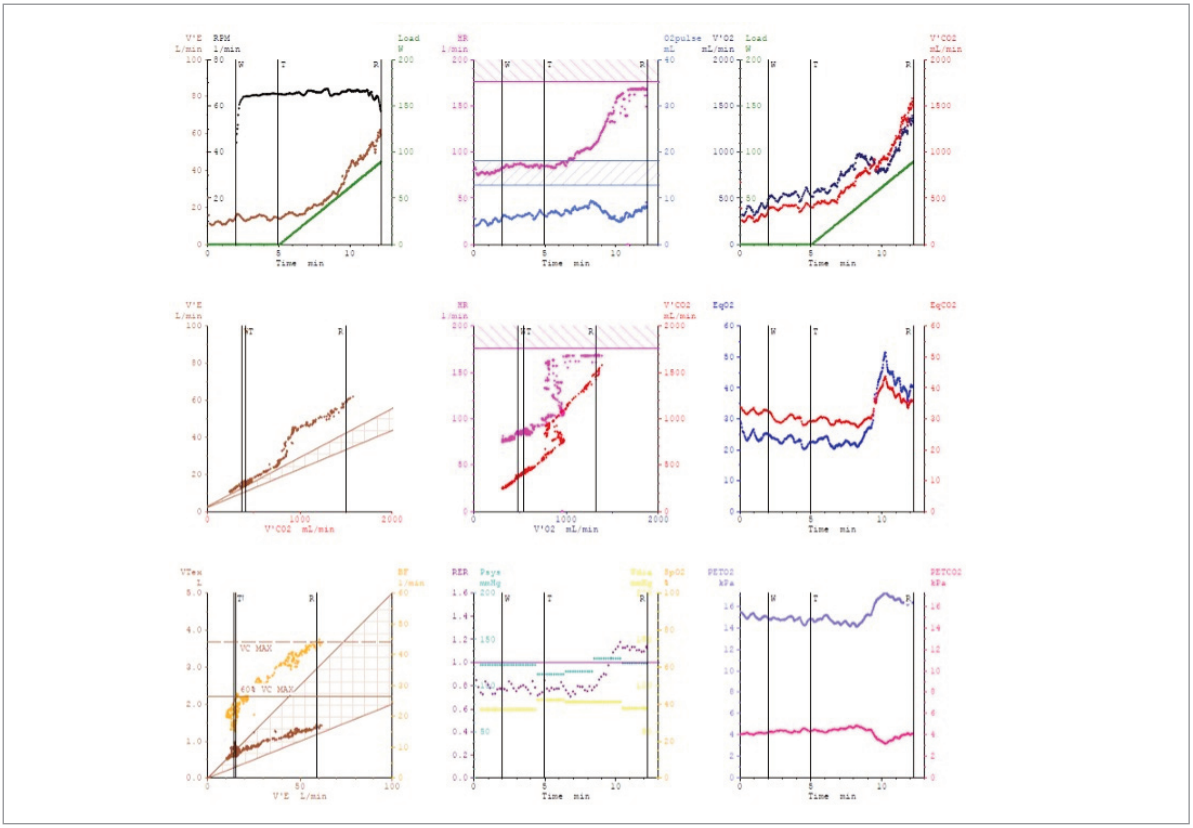

Figure 1. Cardiopulmonary exercise test: 9-panel plot

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plateaued towards peak exercise, suggesting no further cardiac physiological reserve. Peak oxygen consumption was 20.1 ml/min/kg (43% predicted). Resting heart rate was 80 bpm and rose to 168 bpm (86% predicted), and no ECG changes were observed. Pre-test spirometry showed a restrictive pattern and peak minute ventilation (VE) was 56L/min (41% predicted). Oxygen saturation (SpO2) was 96% at rest, with a minimum value of 82% being recorded, whilst peak-exercise SpO2 was 94%. The VE/carbon dioxide production slope was 30.6 and VO2/work rate slope was 7.6. Wasserman's 9-panel plot is shown in Figure 1.

Discussion: The aerobic capacity was severely reduced. The cardiovascular and ventilatory responses to exercise were abnormal, given the temporary loss of oxygen delivery mid-test (Figure 1; Panel 3) and oxygen desaturation. Proposed underlying pathophysiological mechanisms responsible for this are, an increase in aortic valve regurgitation and inability of the systemic right ventricle to increase stroke volume. Consequently, an oxygen debt occurs, with compensatory mechanisms including a sudden rise in heart rate (Figure 1; Panel 2) and hyperventilation (Figure 1; Panel 8 and 9). This case highlights a unique physiological response to exercise given the temporary loss of oxygen delivery in an adult patient who previously underwent a Fontan procedure.

P45

The role of cardiopulmonary exercise tests in a Leicestershire paediatric respiratory cohort.

Mr Joe Madge[1], Natalie Blyth[1], Dr Molla Imaddudin Ahmed

[1]University Hospitals of Leicester Trust, Leicester, United Kingdom

Introduction: In children and young people (CYP) with a background of underlying respiratory disease, exercise induced bronchoconstriction is often considered the likely cause for exercise induced breathlessness (Bahtia et al., 2019). However, cardiopulmonary exercise testing (CPET), considered as the gold standard test to investigate exercise limitation, can be used to investigate potential causes for exercise induced dyspnoea (Ferrazza et al., 2009).

Method: A retrospective evaluation of CPETs performed over 18 months (June 2022-December 2023) was conducted. All CYP were managed by tertiary respiratory services and presented with complaints of exercise induced dyspnoea. CPET's were performed and reported by senior physiologists on a cycle ergometer using a ramp protocol. A maximal CPET was determined using ARTP (2021) criteria.

Results: CPET's from 35 CYP were analysed (median age 13, aged 7-16 years, 22 males (59%)). 30 (81%) of these children were able to complete a maximal CPET. Findings from the CPETs conducted differed in underlying physiological mechanisms (Table 1). Notably, those who had an abnormal cardiac response to exercise also reported dyspnoea and cyanosis of the lips upon exercise.

Finding	Number of CYP
Deconditioned	9
Breathing Pattern Disorder	5
Ventilatory Limited	4
Abnormal Cardiac Response	4
No significant Abnormality	7
Heightened perception of exercise`	1

Table 1: CPET findings

Conclusion: Our analysis highlights a number of differential diagnoses were present in this cohort of patients. This highlights the importance of further investigation to assess any multifactorial conditions causing exercise induced breathlessness in CYP with lung disease.

P46

Using RER values as a retrospective marker of maximal exertion during cardiopulmonary exercise tests: Findings of a single database review

Miss Isobel Briggs[1], Mr Josh Barnes[2], Mr Max Thomas[3], Dr Mark Faghy[4], Dr Karl Sylvester[5]

[1]Doncaster Royal Infirmary, Thorne Road, United Kingdom, [2]Royal Papworth Hospital, Papworth Road, Trumpington, United Kingdom, [3]Birmingham Heartlands Hospital, University Hospitals Birmingham, United Kingdom, [4]Biomedical and Clinical Exercise Research Theme, University of Derby, United Kingdom, [5]Cambridge University Hospitals, NHS Foundation Trust, Cambridge, UK and Royal Papworth Hospital NHS Foundation Trust, Cambridge, UK

Introduction: Cardiopulmonary exercise tests (CPETs) are used to assess surgical risk, functional or peak aerobic capacity, therefore it is vital the individual reaches maximal exertion (Pritchard et al. BMJ 2021). Although there is no gold standard for defining maximal effort (Radtke et al.

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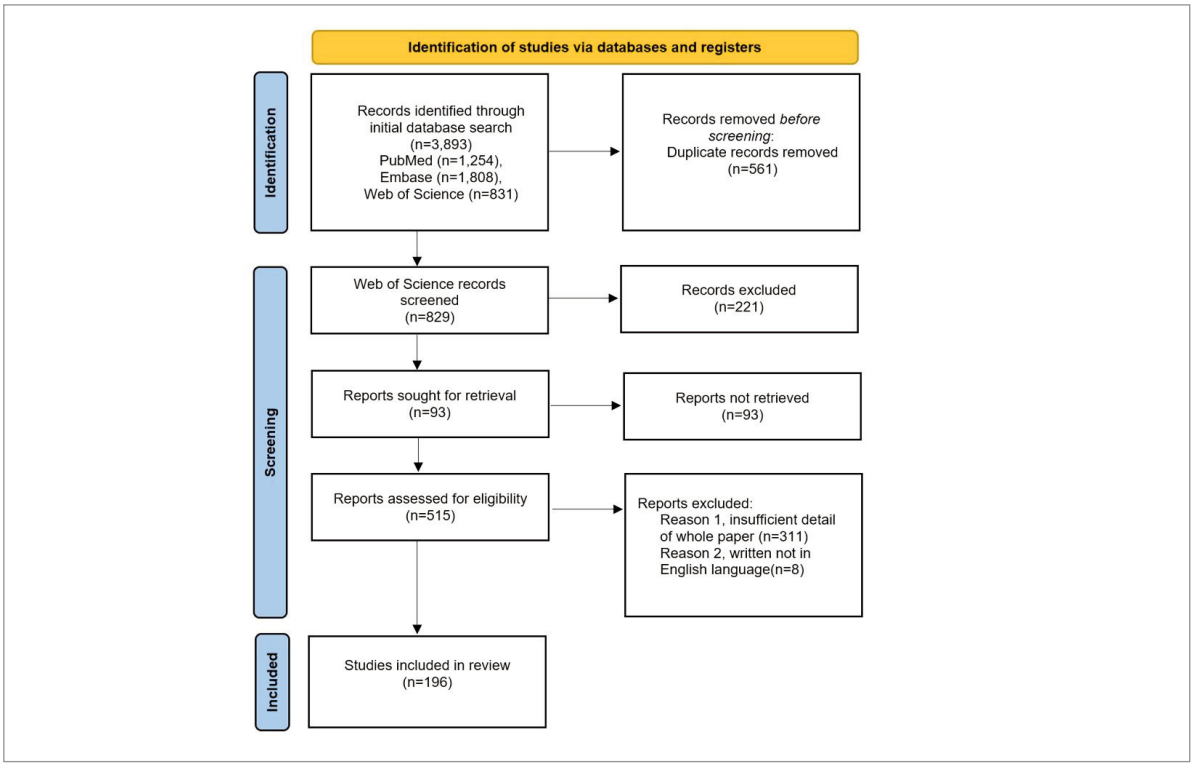

Figure 1. PRISMA 2020 flow diagram showing the study selection process, with only Web of Science records utilised during screening and inclusion

European Respiratory Review 2019) a range of guidelines exist utilising an RER of >1.05, >1.10 and >1.15. Recent findings illustrate a RER of 1.05 or below can underestimate some patients' exercise capacity (Thomas et al. BMJ 2021). The aim of this study was to review the utilisation and consistency of the RER in determining a maximal CPET.

Methods: On the 16 of August 2023 Web of Science, PubMed and Embase databases were searched using: ("respiratory exchange ratio" OR "RER" OR "respiratory quotient" OR "RQ" OR "VCO2/VO2") AND ("cardiopulmonary exercise test*" OR "cardio-pulmonary exercise test*" OR "CPET*" OR "CPEX" OR "CPX" OR "CXT" OR "VO2max" OR "VO2 max" OR "VO2peak" OR "VO2 peak" OR "peak VO2" OR "maximal exercise test*").

Eligibility criteria included studies involving human participants, with an exercise duration of >6minutes. Those included were case, experimental, crossover or parallel studies, randomised or non-randomised studies written in English language, with no restriction on publication year. Exclusion criteria included evidence of dysfunctional breathing, comments on test quality, validity or highly variable RER/minute ventilation and severe illnesses. The RER utilised in each study was compared.

Results: Figure 1 displays the study selection process.

The results show 27% of adults using a cycle ergometry applied a RER baseline of ≥1.05 or below, 52% utilised ≥1.10, 15% utilised ≥1.15 and 6% used a different RER specifically ≥1.09, >1.12, ≥1.13 and >1.20. A RER baseline of ≥1.05 or below, was the highest at 77% in paediatrics using a treadmill. Overall, 33% of the studies used an RER baseline of ≥1.05 or below.

Conclusions: A variety of RER values have been utilised to determine maximal exertion, which lacks consistency in the literature. Furthermore, 33% of studies have utilised a RER baseline of ≥1.05 or below which may result in an underestimation on a patient's true exercise capacity, consequently influencing diagnosis and surgical risk.

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Accuracy of automated BP machines during maximal exercise testing

Mr Daniel Grant[1]

[1]*Leeds NHS, Leeds, United Kingdom*

Introduction: Many centres perform Cardiopulmonary exercise testing, during these maximal exercise tests many centres utilise automated blood pressure monitors to aid testing. Often accuracy is taken for granted however sometimes questionable values are produced and then manually double checked. How accurate are various automated blood pressure monitors? Research (1) suggests only moderate accuracy, is this good enough when decisions may impact surgical intervention. We hypothesised that values would become less accurate with increasing exercise intensity and also in the presence of arrhythmia (significant ectopy, AF). Internal audit performed to verify accuracy.

Methods: We studied the accuracy of the tango M2 automated blood pressure machine with patients exercising on a treadmill, we also studied the built in ergoline Via sprint automated blood pressure machine during ergometer testing and compared resting, mid-test and maximal test values against manually assessed blood pressure measurements taken by experienced healthcare staff. We looked at 22 patients on the treadmill and 45 patients on the ergometer. We looked at absolute difference, percentage difference and standard deviation.

Conclusion: No difference in automated BP measurement in the presence of arrhythmia. No difference in the measurement of automated BP with increase in exercise intensity either on bike or treadmill. We were pleasantly surprised that the automated BP systems worked as one would expect of them both with increasing exercise intensity and in the presence of non-rhythmic pulse thus are reliable rather than just assuming that they produce accurate results apart from occasional erroneous values that are clearly significantly different from others.

Bike excluding arrhythmia

Rest systolic	– AD -0.8mmg (SD 10.6mmHg) - % dif 1.1% (SD 8.1%)
Rest systolic (excluding arrhythmia)	– AD 0.1mmg (SD 9.9mmHg) - % dif -0.4% (SD 7.5%)
Rest diastolic	– AD 4.3mmHg (SD 7.2mmHg) - % dif 5.0 (SD 8.3%)
Rest diastolic (excluding arrhythmia)	– AD 3.9mmHg (SD 7.1mmHg) - % dif 4.5 (SD 8.3%)
Mid systolic	– AD 0.02 mmHg (SD 11mmHg) - % dif -0.3% (SD 7.0%)
Mid systolic (excluding arrhythmia)	– AD 1.9 mmHg (SD 9.5mmHg) - % dif 0.8% (SD 6.5%)
Mid Diastolic	– AD 3.1 mmHg (SD 9.4mmHg) - % dif 2.4% (SD 10.4%)
Mid Diastolic (excluding arrhythmia)	– AD 2.9 mmHg (SD 9.5mmHg) - % dif 2.1% (SD 10.4%)
Max systolic	– AD 3.8 mmHg (SD 23.7mmHg) - % dif 0.6% (SD 13.3%)
Max systolic (excluding arrhythmia)	– AD 1.6 mmHg (SD 15.6mmHg) - % dif -0.2% (SD 10.5%)
Max diastolic	– AD -0.3 mmHg (SD 7.1 mmHg) - % dif 0.6% (SD 9.8%)
Max diastolic (excluding arrhythmia)	– AD -1.0 mmHg (SD 6.7 mmHg) - % dif -1.4% (SD 9.3%)

Treadmill excluding arrhythmia

Rest systolic	– AD 0.2mmg (SD 11.9mmHg) - % dif 0.07% (SD 8.9%)
Rest (excluding arrhythmia) systolic	– AD 1.4mmg (SD 13.4mmHg) - % dif 0.8% (SD 10%)
Rest diastolic	– AD 6.45mmHg (SD 11.4mmHg) - % dif 7.4 (SD 14.7%)
Rest (excluding arrhythmia) diastolic	– AD 9.1mmHg (SD 9.4mmHg) - % dif 11.0 (SD 10.8%)
Mid systolic	– AD 1.1 mmHg (SD 23mmHg) - % dif -2.2% (SD 13.9%)
Mid (excluding arrhythmia) systolic	– AD 6.1 mmHg (SD 24.9mmHg) - % dif 1.1% (SD 14.4%)
Mid Diastolic	– AD 0.8 mmHg (SD 15.4mmHg) - % dif -1.3% (SD 24%)
Mid (excluding arrhythmia) Diastolic	– AD -2.3 mmHg (SD 16.8mmHg) - % dif -6.7% (SD 25%)
Max systolic	– AD 0.9 mmHg (SD 22.7mmHg) - % dif -0.3% (SD 13%)
Max (excluding arrhythmia) systolic	– AD 5.6 mmHg (SD 17.4mmHg) - % dif 1.95% (SD 9.6%)
Max diastolic	– AD 3.4 mmHg (SD 12.2 mmHg) - % dif 0.6% (SD 22.8%)
Max (excluding arrhythmia) diastolic	– AD 5 mmHg (SD 14 mmHg) - % dif 1.3% (SD 26.9%)

Reference

1. Diagnostic accuracy of mercurial versus digital blood pressure measurement devices: a systematic review and meta-analysis. Muniyandi et al. Scientific reports. 2022

ARTP c/o Executive Business Support
Unit E1, City Wharf, Davidson Road,
Lichfield, Staffordshire, WS14 9DZ
Tel: 01543 442141
E-mail: admin@artp.org.uk
Website: www.artp.org.uk