ARTP Association for Respiratory Technology & Physiology

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# INSPIRE

## HIGHLIGHTS ...



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# CONTENTS

# First word

Dear Readers,

Welcome to the winter edition of INSPIRE. This edition features the conference respiratory abstracts, which have already been published in the *BMJ Open Respiratory Research* (BMJORR), but we decided to stick with tradition and also publish them in INSPIRE.

One of the conference abstracts has been submitted as a full article, exploring the utility of CPET in predicting survival in patients with AAA. I saw this abstract during one of the poster sessions at the ERS in Amsterdam and was very impressed. I'd like to thank Ryan Pettifer for writing up his article and congratulate him on some excellent research. This was his STP thesis, and it demonstrates the high-quality output of Clinical Scientists that we are getting from the STP programme.

We have our regular features with **'Lab in the Limelight'** , which gives an insight into the fun, hardworking lab in Wye Valley, led by Shirley Coelho. After Trefor Watts submitted his 50-year career summary for the last edition, I thought it would be ideal to expand on this and interview him for **'Respiratory Life Stories'**. **'Fresh Air'** looks at research committee member Mollie Riley's research experience and PhD journey—an inspirational read for any junior or aspiring researchers. **'On the Blower'** has some manufacturer news, including an interesting challenge completed by Harry Syson of Love Medical. Finally, I have included the penultimate instalment of **'Getting to Know the ARTP Committee Chairs'**, focusing on our Equality, Diversity & Inclusion and Research & Innovation committee representatives.

A special mention goes to my predecessor and current member of the editorial committee, Aidan Laverty, for his editorial expertise—this edition would not have been possible without it. I hope to see some of you at National Strategy Day and, if not, perhaps in Belfast for next year's conference.

**Paul Burns**
**ARTP INSPIRE Editor**
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# A Word from the ARTP Chair

**Dr Joanna Shakespeare**
*ARTP Honorary Chair*

**Hello and welcome to the final edition of INSPIRE for 2025. Moving into winter is always a busy time, particularly for staff supporting those with respiratory conditions. For ARTP it also coincides with a range of events including the ARTP National Strategy Day (NSD) and the Winter British Thoracic Society (BTS) meeting. This year sees the addition of a Four Nations strategy event and an ARTP committee members day.**

At last year's strategy day, we launched the Four Nations-specific breakout sessions to better support members from all corners of the UK. This year, to support the wider membership and to decrease travel requirements, we have moved this aspect of the NSD agenda to an online event which was held on 11th November. Lots of changes are occurring across the nations including the new 10-year plan in England, the Scottish Redefining Our Workforce initiative, a focus on professional registration in Wales and a wide range of initiatives in Northern Ireland to raise the profile of Respiratory and Sleep Sciences. Moving this event online allowed us to share these initiatives with a wider audience. In addition, July 2025 saw a change in leadership at the Academy of Healthcare Science with Prof Chris Hopkins taking up the role of President. Chris outlined his role and work to date and the Academy's strategy for his tenure, with many of the Academy's aims and ambitions linking very well with the current ARTP strategy.

Our Vice Chair, Matt Rutter, has developed an ARTP committee's day which is being held on 19th November. This is an online event, bringing together all members of all ARTP committees to support communication and cross-committee working. The outcomes of this meeting will enable the development of committee objectives for 2026/2027, preventing duplication and fostering collaboration toward our aims and ambitions. The findings from this day will also allow us to update our strategy progress charts in preparation for the NSD event.

The 2025 National Strategy Day will be held in Birmingham on 12th December. Historically, this was free to attend for all heads of service and/or deputies; however, the significant increase in costs associated with venue hire has resulted in us having to charge a fee of £25 per delegate. This has, however, allowed us to advertise the event now as available to all departmental representatives. This year's event will provide a focus on the work of some of ARTP's committees as well as skills workshops and innovation case studies. We will also provide an update on where we are with our strategy objectives and where our focus will be

for the next 12 months to ensure that we continually look to deliver against our planned objectives.

The BTS Winter meeting is being held on the 26th to 28th November in London. Each year the ARTP presents the work we have undertaken in collaboration with the BTS throughout the year at the Specialist Advisory Group (SAG) meeting. Our SAG is scheduled for 9am on 28th and I would like to encourage any members in attendance to come along and see what we have been doing and our plans for the next 12 months.

Away from events, we have recently launched the ARTP Fellowship programme. This sees a rebranding of the ARTP special awards to ARTP Honorary Fellowships. In addition, we are launching a fellowship programme aimed at identifying those individuals who dedicate their time and effort to the work of ARTP and also in support of its members. Our first window for applications will open in spring 2026, so watch this space.

The final big venture for 2025 will be the launch of the new ARTP website. We are very close to launch but want to ensure that where possible we have updated as much of the content as possible. However, the membership features are a significant improvement over our current capabilities and will make it much easier for us to understand our membership and, importantly, to communicate better.

Finally, a little save-the-date reminder. The ARTP 50th Anniversary conference will be held in Belfast on 21st and 22nd May 2026. Hopefully, many of you were inspired by those whose 2025 abstracts were published in BMJORR and are working hard to have your abstracts submitted before the deadline of 13th February 2026.

We will also be holding our inaugural ARTP Spirometry conference which will coincide with Day 1 of the main conference. We hope that this will become an annual event and will provide support, updates, and spirometry best practices to practitioners in the local area and further afield.

As always, I would like to continue to encourage members to communicate with myself (chair@artp.org.uk) or specific Committee Chairs (via admin@artp.org.uk) as much as possible. Please feel free to ask questions, raise comments or concerns where required.

I will leave you now to enjoy this edition of INSPIRE. I would like to take this opportunity to thank you all for your hard work and dedication to patient care in these continued difficult and challenging circumstances. I will also take this opportunity to wish you all a happy and healthy New Year and I look forward to working with many of you in 2026.

# Respiratory Life Stories

**Trefor Watts**

*Interview with INSPIRE Editor - Paul Burns*

**For this edition of INSPIRE, I spent a couple of enjoyable hours chatting with Trefor Watts about his life and career after recently celebrating 50 years in the NHS. We could have chatted for another few hours on all the topics we covered, but time and article length limited us! Many of you will have read Trefor's article in the August edition, where he detailed his 50-year career in the NHS. I thought this was a good opportunity to delve into some of the career details and interview him for this edition.**

He is a respected respiratory healthcare scientist whose decades-long career has shaped services and training across the UK. From his beginnings in medical physics and nuclear medicine to leading respiratory physiology and developing innovative services, Trefor's story offers a fascinating look into how curiosity, leadership, and lifelong learning drive excellence in patient care.

Trefor actually assessed me in 2007 for my ARTP Part I clinical viva for which I had to travel to Glenfield in Leicester to do. I think I was last in a long day of examinations but I distinctly remember him being a very friendly and fair assessor and thankfully he passed me! Trefor's story is a testament to his commitment in delivering the best service for his patients. His journey—from lab technician to respiratory leader—mirrors the evolution of healthcare science itself: increasingly complex, yet deeply human.

**You mentioned in your article that your healthcare science journey began more in the labs than in physiology. How did that early experience shape you?**

*I started in the labs at Walsall Manor Hospital because I had a fantastic chemistry teacher who really sparked my interest in science—but my biology teacher was not so good! So, chemistry and maths came naturally, and I wanted to do something scientific within the NHS without becoming a doctor or a nurse.*

*When I looked at the available jobs, the labs gained my interest, so I applied for a job there. This meant my first exposure was in the pathology labs, working in radioimmunoassay testing. But even then, I realised the labs were becoming a production line—less human contact, more automation. It was a point of luck or destiny, maybe, that I had not done well in biology as it meant I wasn't able to apply for a training programme in the pathology lab.*

*Whilst I was in the labs, I got to see all the departments, and one which interested me was nuclear medicine. When I looked into it, I discovered the profession of medical physics. What I loved was patient interaction, so this felt like the right balance between science and people.*

**Was that when you started in Medical Physics and Physiological Measurement (MPPM) training?**

*I was the sole worker in the new Nuclear Medicine department at Walsall. At the same time, the respiratory lab was just getting going and it was also just one person working there. Sometimes they needed help if, for example, they were doing an exercise test so I was asked to help out with this. It was then I realised physiology had an even stronger patient-facing element. That became a turning point for me.*

*Yes, exactly. I joined the MPPM (medical physics and physiological measurement) training programme. It gave me the foundation to explore both the physics and physiology professions. I initially gravitated towards nuclear medicine.*

**What drew you to respiratory physiology in particular?**

*As part of the MPPM programme, you undertook a week in the four physiological disciplines, then a week in four medical physics disciplines. I completed rotations through different specialisms of medical physics and physiology in different hospitals in Birmingham and Coventry.*

*After these short placements, I had to decide whether to specialise in physiology or medical physics. Although I had really enjoyed the physiology, particularly respiratory, I chose medical physics, partly because I had been working in the nuclear medicine department and had very little experience of physiology.*

*There were six of us on the programme, and most chose medical physics; therefore there wasn't enough positions at the end of it the two years. As it so happened, the person whom I had helped in respiratory at Walsall was leaving to have a baby therefore there*

*was a post available which I successfully applied for. It was all a bit of fate really as I had found that with nuclear medicine the patient would come in, and you would get them to lie still and take different images, whereas, as we all know, with respiratory physiology, we had to motivate, encourage and instruct patients to do various breathing techniques and exercise tests. I've always liked dealing with and speaking to people, and in respiratory physiology, you need to build trust quickly—help patients relax, sometimes motivate them, sometimes just listen. You also end up learning a lot about people's lives. Respiratory just clicked-the blend of technology, physiology, and personal contact made it feel alive.*

*So, I was around 21 years old, had got married, and returned to Walsall in the respiratory department as a respiratory technician which was meant to be a short-term post but turned into a forty-year career!*

**Were you the only respiratory technician in the department at this point?**

*Yes, and I had fallen in love with respiratory, so I was really enjoying it. Part of the reason for this was a mentor I had when I started. He was a respiratory consultant called Dr Ramesh Joshi. He taught me so many things, and he was passionate about teaching. He wanted to teach everyone, and he was a real inspiration.*

**You've mentioned being something of a "one-man department" at the start. How did you go about building and developing that service?**

*Yes, in those early days, it was literally me and Rob Thompson—and occasionally someone helping out from cardiology. But it was an exciting time because district general hospitals (DGHs) were full of opportunity. You had to work with everyone—clinicians, nurses, technicians—to make things happen. Management didn't like talking to multiple clinical workers; therefore they wanted to appoint one person to be in charge. I liked the idea of management and being able to shape the service, and Rob was quite happy testing the patients without any of the management aspects, so they appointed me as the senior.*

*At the same time as me becoming senior in the department, the hospital appointed a new cardiologist, which meant the clinical team comprised one of each: respiratory consultant, cardiologist, gastroenterologist, elderly care physician, and a diabetes consultant. The new cardiologist approached me to say they were having trouble recruiting cardiac physiologists. One thing I learned early on and pushed hard for was becoming a training centre to help with recruitment. Smaller hospitals needed to attract students and trainees. We took on work experience students, trainee physiologists, and created an environment where learning was part of the job. The respiratory and cardiac consultants got together and decided it would be a good idea to combine the departments to help with staffing and resources. They also added neurophysiology into the mix, as there was only one physiologist in that department as well.*

*This gave rise to the Clinical Measurement Unit (CMU), which brought together respiratory, cardiology, and neurophysiology under one structure. Initially, it was run and manged by the individual leads, who were what would be equivalent to your band 6 these days. It was decided that it would function better with someone overseeing all the departments of the CMU, and that was where I began my management career. I was initially offered the post on a twelve-month temporary basis then they reviewed it and the management decided that, as I had had done a good job and nobody else really wanted it, they would offer it to me on a permanent basis.*

*It helped greatly that I had experience in all the disciplines. For example, I had learned to do ultrasound from my time in nuclear medicine, had experience in EEG and nerve conduction studies, and had my wealth of experience in respiratory. Taking on that role was a big leap—suddenly managing several disciplines, recruiting staff, and developing training pathways. Challenging but exciting!*

**Was management something you always aspired to, or did it evolve naturally from your clinical work?**

*It evolved naturally. I never set out to be a manager. I liked organising things, problem-solving, and making services better—that's really all management is.*

*There was a lot of quality auditing happening at this time in the hospital, so I managed to get involved and get some experience of this through the help of the nurse director. I also worked with an estates director who taught me about his role. It let me see all the different problems these different professions had, which was similar to scientists. One issue in healthcare science is that we often don't see outside our profession and can become quite insular, but the problems we face in physiology can be related to the problems other hospital services face, and it is good to speak to other disciplines to help with your knowledge and experience.*

*It's hard in the NHS to reward staff, as you don't have access to the same resources that you do in private industry, and I remember discussing this with the hospital chief executive. At one point I had worked seventeen years without any sick days and the Chief executive wanted to celebrate this. There was also a porter who had only had one or two days off in twenty years. I told them to give him the award as I felt it was more important for the organisation and I didn't want the recognition.*

*I was leading the CMU and had been doing so for around ten years at this point, but still doing clinical work. One of the smartest things I did was to negotiate*

*to keep at least 50% of my time clinical. That balance kept me grounded. You can't manage effectively if you're out of touch with what your staff and patients experience day to day. Then the hospital encouraged me to take on broader responsibilities. I was about thirty years old and had started a postgraduate Master's in Business Administration (MBA). Eventually, I became a clinical services manager, overseeing physiotherapy, dietetics, occupational therapy, photography and dental, as well as physiology. I also worked with imaging and pathology. I got to know about how all these other disciplines worked, which was great experience. I was still leading the CMU but now also responsible for overseeing the management of all these other departments. I did this for around two years, then took a step back and handed it over to a new person, as the post was seen as a temporary development opportunity.*

**How big was the respiratory department at this point?**

*There was a senior and 1.5 basic grade, so three people. However, one of the ways I learned to help with recruitment was to have a dual-post, so there was someone who worked half the week in neurophysiology and half the week in respiratory. She was re-appointed to full time in respiratory. We also had a lot of trainees rotating through our departments, which helped. Claire Hill became the lead respiratory physiologist.*

**What innovations or developments in respiratory diagnostics are you proudest of from your time in Walsall?**

*There were a few. When Dr Joshi started, he bought the first ever "Model B" PK Morgan PFT system. Early on, we brought in histamine challenge testing, exercise-induced asthma tests, and cardiopulmonary exercise testing, which was cutting-edge for a District General Hospital (DGH). We also did hypercapnic and hypoxic response studies and developed an early interpretive computer program—what you might now call an early form of AI—for blood gases and full PFT interpretation. A lot of the development work was driven by Dr Ramesh Joshi, and he would ask the question, of "Can we do this" and I would use my scientific brain to try and solve the problems he was coming up with!*

*I remember during my training days in nuclear medicine, we had a patient come for a bone scan and it was all clear—no abnormalities. He also went to the X-ray department, and they performed X-rays which showed widespread, very small secondary nodules! Because it was so widespread, it had made the bone scan seem normal. This taught me early on that there are limitations to any measurements you make, and they can never just be interpreted in isolation, just like PFTs.*

**Which sleep services did you provide at Walsall?**

*We performed the diagnosis and treatment. We did a lot of pulse oximetry and multi-channel home studies. The GP would refer to the consultant, who would send them to us for the test before seeing them, and if they were positive we would get them started on CPAP. Sometimes by the time the consultant saw them they were already sorted. It was a bit like a physiologist-led clinic before its time!*

*At first, we didn't have funding for the CPAP devices, so I worked with the local League of Friends charity to buy the first fifteen CPAP machines. After a public lecture, including a video loaned by Dr Martin Allen, the League literally wrote a cheque on the spot—they saw how much patients were struggling. That support helped us start one of the first sleep services in the region. We hadn't realised how big a problem OSA was.*

*We proved that most patients could be diagnosed and treated effectively using oximetry and home-based assessments, without needing full polysomnography. That was a huge step forward in accessibility. I remember having debates with Brendan Cooper and Adrian Kendrick about not requiring fancy, full polysomnography to diagnose OSA.*

**Tell me about the West Midlands quality control Programme**

*In the West Midlands, an early project by a registrar with support from physiologists visited all twenty-three departments in the West Midlands, and were tested on their equipment. I got involved ten years later for a review where we did similar things but also added some calculation aspects. We noted a lot of quality improvements resulted from this project. To give you an example, in one department we found that the demand valve to do the gas transfer test was so tough to activate it that very few patients could do it. They were an isolated department therefore they just thought this was the norm. Alan Moore knew the manufacturer and got the problem sorted for them. Keith Butterfield was the computer genius and statistician behind it all, and when he moved down to Dorset, he started up a similar programme there with Adrian Kendrick, and this eventually became ARTP standards to have a biological QC programme which checked the equipment in all the hospitals in your area. It helped to try and standardise how different departments were working. In another department, we found a testing room had been painted and the painter had put the stadiometer back on the wall 5 cm out!*

*The third iteration of the ten-year cycle helped identify issues that manufacturers had with incorrect reference equations or problems with different versions of software. We relayed this information back to the companies, and this started what eventually became the Manufacturers Liaison Committee.*

**Tell me about your involvement and roles within the ARTP and RCCP**

*I wasn't heavily involved in ARTP committee work, and the people who were in place at the time were in those*

*roles for a while. I have always had a passion for training and developing people; therefore I gravitated towards this and joined the education committee. I still remember the day when Adrian Kendrick and I bumped into each other at Derby railway station for our first education committee meeting, and astonishingly, to this day, we are both still on it!*

*Because I was keen for Walsall to be a training centre, I thought getting involved in the education side of things locally would be very helpful and important. I also started lecturing at the Matthew Boulton College, Birmingham, and at the university. From there, I gravitated towards helping establish and set up the ARTP Part I and Part II examinations. I did a lot of work at this point with our current chair, Jo Shakespeare. I was also involved in standards and helping set up ARTP courses.*

*The education board wanted someone to go onto the Registration Council for Clinical Physiologists (RCCP) Professional Body Education Committee (PBEC), which was an arm of the RCCP that had representation from each of the physiology disciplines and HEIs. Moving into the early 2000s, the position became available for chair of the PBEC committee. As I was passionate about education, I put my name forward and got the position. I started to learn more about statutory regulation and the fight that was going on to get it. Then the Academy for Healthcare Science (AHCS) came along, and there was all the politics involved in the competition between them and the RCCP to hold the voluntary register for physiologists.*

*When I was chair of PBEC, I was approached to become vice chair of RCCP. It was becoming less likely we would get statutory regulation. The motion had been through the Privy Council and was turned down at the last moment, even though the Health Care Professions Council (HCPC) recommended that clinical physiologists should be statutorily regulated due to the increasingly important roles we were playing within healthcare and in the diagnosis and treatment of patients. I realised that it was important for RCCP to gain 'Accredited' status for their register.*

*I felt sorry for the professions at the time, and people would ask "Which register should we go with?" Some people didn't feel strongly about either, and some did. I think it was hard for Brendan Cooper, as he was a founding member of the RCCP but had become president of the AHCS. I explain in my previous article how this eventually turned out.*

*One of the great things the academy did was to gain HCPC statutory regulation for new clinical scientists, and current physiologists could gain it through the equivalence process. If we'd worked together on that, 50% of the RCCP membership would have gained this. Brendan and I were trying to work together to bring the two organisations together.*

*I truly feel that any healthcare professional who has autonomy to act should be statutorily regulated. One interesting point on regulation is that nurses, physiotherapists, etc., only require an undergraduate degree to get their statutory regulation, whereas in terms of physiology and clinical scientists, they have to be educated at Master's level. I believe the level should be set at Master's for all these professions.*

*Trefor chairing an ARTP conference session*

*The prescribing issue is another problem. We will give patients various medicines like oxygen and nebulised therapy. The irony is that a physiotherapist or nurse wasn't allowed to give a patient nebulised treatment, but I could because I wasn't HCPC registered! This is what annoys me about the politics of it all. There is the need to change, but not the will.*

**How did the AHCS manage to get statutory registration for Physiologists (through the Clinical Scientist route)?**

*The AHCS was to be one voice to represent all the healthcare sciences. It was driven by Sue Hill, and the one voice was important at government level to strengthen any arguments we had. Just like, for example, nurses, therapies and pharmacists have one voice, which is stronger. The Academy had to fund physiologists becoming clinical scientists with statutory regulation. Initially, there was start-up money provided by the Department of Health. To continue funding this, the idea was to provide a voluntary register for healthcare science groups that didn't have statutory regulation. However, they missed exercise physiologists who are qualified at Master's level. They had people on the board who were representing clinical scientists from different areas like physics and pathology, and people like Brendan were representing physiology, so they had some clout!*

*Then they applied to HCPC to be an awarding body, i.e., they were able to award certificates to those whose previous training and experience are deemed equivalent to the formal STP program. This allowed them to be financially viable. They also had the political support.*

**You mentioned in your '50 years and still going article' that you were very proud of setting up and developing the pulmonary rehabilitation service in the West Midlands. Could you tell me about this?**

*Whilst I was working as clinical services manager and leading the CMU, I was asked to lead on developing the pulmonary rehab service. Again, Dr Joshi was the*

*driving force in it, and it was prior to the BTS publishing their guidelines on pulmonary rehab. I had some discussions with Professor Mike Morgan and physiotherapist, Sally Singh who were leaders and researchers in the pulmonary rehab field. We put together a team and had to get funding to get the first cohorts through. We managed to get funding from a pharmaceutical company and the commissioners to get it going for the first two years, with the commissioning group promising to pick up the full tab if it was successful. It helped that we had a very good chairperson of the hospital, who actually managed to get Princess Diana to officially open our hospital. Dr Joshi sat down and looked at all the evidence to make a plan and we put together a programme which was about 90% similar to what the BTS eventually published. We got physios, psychiatrists, and occupation therapists (OT) all working together.*

*The physios' job was to teach the patients to understand what was going on with their bodies, specific exercises to do, and breathing techniques. The OTs were interesting, as they focussed on something known as 'The Activities of Daily Living'. This is where you ask someone, "What do you want to have been able to do by the end of the day?" The most common answers were: "I want to go dancing in the afternoon", "I want to be able to play with my grandchildren" or "I want to be able to walk my daughter down the aisle". It is essentially goal setting, and I had never even thought about this. The psychologists focussed on coping strategies and depression due to the diseases, which was highly prevalent and what to do if you have a panic attack.*

*We put the first group through. Seven out of ten completed the programme, which consisted of sessions twice per week for six weeks. Well, I was converted after this! I could not believe how both physiologically their exercise capacity had improved, but also their psychological improvement and their control over their disease. They talk about the negative feedback loop of chronic lung disease and deconditioning, and I could see how important this was. It was also important to have the respiratory scientists involved as they did the initial and final assessments in the patients.*

*It all worked really well, and eventually the BTS guidelines came out. There were two things that we hadn't included that were in them. One was an initial session on education with a session on disability allowances, and the second one was talking about end of Life. Initially, I thought this was not needed but then I spoke to a palliative care consultant called Dr Esther Waterhouse. She got me thinking about how I would want to die if I was diagnosed with a life-limiting condition. I always think back to a patient I saw in my oxygen clinic who had pulmonary fibrosis and had a transfer factor less than 25%, therefore likely had around twelve months to live. He came with his wife. He was a self-made millionaire, had worked in and owned a factory. He was very good to his staff, paying for their mortgages. He wanted to go abroad and came along for a flight assessment. He was needing more than 4 L/min, so I told him he wouldn't be able to fly. When I realised he wanted to go somewhere in Europe, I told him that he could easily go on a cruise to his destination. So, he went off and bought a concentrator, went on holiday, and had a great time. The second thing he wanted to do was walk his daughter down the aisle. She was due to wed in eight months' time. Well, I said, with a bit of work we can get you through that. The last thing he wanted to do was to see his next big wedding anniversary. It was in two years' time. I had the confidence to tell him that the odds were he wasn't going to make that, bearing in mind that this was before the new treatments were available for pulmonary fibrosis. He came back to see me twelve months later, and he had done the cruise and walked his daughter down the aisle and was really happy. He didn't show for his next appointment but had passed away. His wife came into see me and thanked me for telling them the truth about the treatment and what would happen. She said "You told us what we could do, which we had a fantastic time doing, and you were honest with what we wouldn't be able to do." It is a shame that we are not trained on how to deal with or speak to patients about this as scientists.*

### Tell me some people who have been inspirational in your life and career

*I have mentioned him several times already in this interview, and he undoubtedly was an inspiration: Dr Ramesh Joshi. He was from India, studied there and gained an MD. He moved to the UK and gained a Commonwealth fellowship to work with the pioneers of respiratory medicine in America. He moved to America, then moved to Birmingham and eventually settled at Walsall. He taught me so much about medicine and how to treat patients. He was a perfectionist when it came to research.*

*I need to mention Brendan Cooper, Adrian Kendrick, Dr Mike Morgan, and Dr Martin Allen. They have all been very influential in what I do in respiratory. Martin Griffen, who was a lecturer at Matthew Boulton College had a way of teaching people the basics, and I learned a lot from him.*

*Another really proud moment for me was when I was awarded the ARTP Special Achievement Award in Hinckley in 2009. Being recognised like this by my peers was a real honour.*

*I also wanted to mention a bit about DGHs. Most of my training was done in specialist regional centres, as a lot of the work was only done there. Specialist centres tend to be at the cutting edge of science, and DGHs are more involved in the day-to-day practical side of seeing the patients. We know a lot more people outside the bubbles of our departments within the*

Trefor and Brendan Cooper hard at work during conference in 2004

*hospital, which I think is a real positive of DGHs. Taking some experience from all the people who come through the department and allowing the trainees and students to challenge me scientifically and sometimes they can be better than you are!*

*I also need to mention the patients I've met over the years. They are wonderful people. Don't get me wrong, they can be a pain in the backside sometimes, but this is usually because they have been treated poorly elsewhere in the NHS or are scared. The patient is the most important person in the hospital, and if you don't think about the patient, you are not a good clinician.*

**Looking back, what do you think has changed most about respiratory physiology and healthcare science as a career?**

*The technology, of course, but also the recognition of healthcare scientists. When I started, we were often seen as "backroom people." Now, there's a real understanding of the science behind diagnostics and the patient benefit it delivers.*

*Another change is the structure—training, accreditation, career frameworks—all far more formalised now. That's good, but I do think we've lost some of the "learn by doing" experience. Back then, if you wanted to expand a service, you just figured it out.*

*I tell new physiologists: never lose your curiosity. The best ideas come when you ask, "What happens if we do this differently?" That mindset took me from a one-person lab to managing multidisciplinary teams and shaping regional services.*

**You've had a long and influential career. What advice would you give to someone just starting out in respiratory physiology?**

*Be open. Learn from everyone—consultants, patients, colleagues. Patients especially teach you things no textbook can.*

*Also, don't be afraid to take opportunities outside your comfort zone. I never planned half of my career steps—they came from saying yes when someone asked for help. And stay humble. Leadership isn't about authority; it's about helping others succeed.*

**And now that you're retired, what does life look like for you?**

*Retirement's wonderful! I still do a small part-time role, about a day a week, as the West Midlands Clinical Lead for Home Oxygen, which keeps me connected to the field.*

*Otherwise, I'm enjoying having my evenings and weekends back. It's only when you stop working full-time that you realise how intense it was. Now I can contribute in smaller, meaningful ways—and that feels just right. I have five grown-up children, one daughter and four boys, three of whom are chefs. My wife did all the hard work in bringing up the children whilst I was working. I have two grandchildren who are fourteen and eleven. They live just up the road and keep my wife and me busy. We bought a house in Wales when I retired, so we often take the grandchildren there on holiday. I am actually trying to learn Welsh at the moment, but it is a hard language!*

## QUICK FIRE QUESTIONS

**Favourite food & drink?**
*A nice steak with a bottle of red wine. I also like my whisky.*

**Celebrity crush?**
*Julie Christie (British actress) from my youth.*

**Favourite film?**
*The Rocky movies.*

**Nicknames?**
*In management, people would often say JFDI (Just F****** do it). Otherwise, I get called "Tref"*

**Favourite pastime?**
*Distilling wine and spirits.*

**Karaoke song?**
*Frank Sinatra – "I Did It My Way"*

**Favourite holiday destination**
*Italy, Naples.*

**Favourite memory?**
*Birth of my children. Seeing my children grow up.*

**Biggest bugbear?**
*People who do not do their job to the best of their ability.*

ARTP Association for Respiratory Technology & Physiology

ANNUAL CONFERENCE 2026
21-22 MAY 2026 ICC BELFAST

50th Anniversary

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# The Utility of CPET variables for Intervention Stratification and Survival Prediction in High-risk AAA Patients

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**Abstract**

Controversy remains regarding the optimal intervention strategy; open surgical repair (OSR), endovascular repair (EVAR), and conservative management (CM) for high-risk abdominal aortic aneurysm (AAA) patients. This study investigated whether CPET parameters could predict post-intervention survival, requirement for re-intervention and facilitate intervention stratification in high-risk AAA patients.

**Method**: This retrospective study included high-risk patients ($\dot{V}O_2$ at the anaerobic threshold <11ml/kg/min) with an AAA ≥5.5cm, who performed CPET and received AAA intervention between 2014 and 2021 (n=82). Kaplan-Meier survival analysis, multivariate Cox proportional hazards regression, and receiver operating characteristics (ROC) were conducted.

**Results**: Kaplan Meier analysis found superior 5-year survival probability for EVAR compared to OSR and CM (79% vs 66% and 50%, respectively). Significant associations and hazard ratios were found for $\dot{V}O_2$ Peak and pulse pressure at peak exercise (P-Pex) with survival time, in the cox proportional hazards model. With $\dot{V}O_2$ peak and P-Pex indicating 33% and 2.2% reduced mortality risk per 1-unit increase, respectively. ROC curves for long-term survival prediction revealed thresholds for $\dot{V}O_2$ peak (AUC=0.73) and P-Pex (AUC=0.722) of 16.6ml/min/kg and 92.5mmHg, respectively. ROC for $\dot{V}O_2$ Peak as a model to predict EVAR survival greater than CM survival (AUC=0.78) demonstrated a threshold of 14.5ml/kg/min.

**Conclusion**: EVAR offered a survival advantage compared to OSR and CM. Reduced $\dot{V}O_2$ peak and P-Pex indicates poor likelihood of long-term survival following EVAR in high-risk patients. A threshold of 14.5ml/kg/min $\dot{V}O_2$ Peak may be used to help stratify which patient should receive EVAR and which should receive CM.

Keywords: Abdominal Aortic Aneurysm, CPET, Survival, Intervention Stratification, Biomarkers.

## Introduction

### Abdominal Aortic Aneurysms

An aneurysm refers to a focal dilation of an artery wall.[1] Aneurysms develop due to loss of vascular smooth muscle cells and degradation of the extracellular matrix, through proteolytic and oxidative mechanisms, resulting in thinning and dilation of the vessel wall under pressure.[2]

Abdominal aortic aneurysms (AAA) are the most common aneurysm with epidemiological reports indicating 2.8 to 8% prevalence.[3-5] Ruptured AAAs pose significant risk to the individual with in-hospital mortality rates of 53.1% and 65.9% in the USA and England, respectively.[6] However, 34% of people never reach hospital, cumulatively resulting in an associated mortality rate of up to 80% in the event of AAA rupture.[6,7] Therefore, establishing an individual's rupture risk and intervening prior to rupture has been a focus of AAA research and management over the last 50 years.[8]

### Interventions

The three treatment modalities for AAAs are open surgical repair (OSR), requiring general

anaesthetic, open access to the abdomen, and clamping of the aorta above the aneurysm site prior to repair;[7] endovascular abdominal aneurysm repair (EVAR), a minimally invasive procedure which requires percutaneous access through the femoral artery to the aneurysm site, where a stent graft is then positioned inside of the aneurysm effectively acting as a new vessel wall, preventing further expansion;[7] and conservative management (CM), with no surgical intervention, focusing on reducing risk factors and burden of associated comorbidities.[7]

Historically, OSR was the mainstay intervention for AAA repair with an associated elective perioperative mortality rate of ~5%.[9,10] In 1999 the EVAR-1[11] and EVAR-2[12] large-scale randomised control trials (RCTs) were commenced to evaluate the efficacy of EVAR. The EVAR-1 trial found superior operative and 30-day mortality rates for EVAR compared to OSR (1.8% vs 4.3%, respectively). However, at 6 years post intervention EVAR offered no survival advantage, with cost analysis identifying that EVAR was more expensive in the long-term due to requirement for re-intervention (RfR).[11] EVAR has complication rates as high as 30%, which include endoleaks, graft migration, collapse, kinking or stenosis, ischaemia, cerebrovascular and cardiovascular events, with RfR being regarded as a primary factor associated with worse long term outcomes.[13] Surgeons, however, have continued to utilise EVAR for its assumed advantages in perioperative morbidity, mortality and recovery in patients with greater pre-existing morbidity.[14] Despite the findings of the EVAR-1 trial, EVAR accounted for 66% of elective AAA repairs performed within the NHS in 2013, with data obtained from 81 NHS trusts.[15] As a result, the National institute for Health and Care Excellence (NICE) issued new guidance on AAA diagnosis and management that recommended the use of OSR as the primary intervention for AAA repair. Advocating for EVAR and CM equally in patients with increased anaesthetic/operative mortality risk.[16] These recommendations were based upon the medium and long-term harms of EVAR compared to OSR and CM, which NICE regarded as outweighing its short-term benefit predominantly based on the findings of the EVAR-1 trial.[16]

Interestingly, there remains controversy in the literature with other large scale RCTs reporting similar albeit better long-term outcomes for EVAR compared to OSR. Indeed, a criticism of the conclusions of the EVAR-1 trial,[11] which has heavily influenced the NICE guidelines, is that the participant sample included older patients with larger AAA than all other large scale RCTs conducted (Table 1). More recently however a meta-analysis of RCTs comparing outcomes of EVAR and OSR concluded that based on the current evidence EVAR offers superior outcomes within the first 6 months but carries increased risk of aneurysm-related mortality in the long term (>8 years).[14] However, the authors acknowledged that the inclusion of the EVAR-1 trial (the largest RCT) dominated the results of the meta-analysis.[11]

Table 1: Literature summary table of RCTs comparing EVAR to OSR; *=median.

| Trial, year, country, journal | Centres | EVAR (AAA diameter (mm)) [age] | OSR (AAA diameter (mm)) [age] |
|---|---|---|---|
| ACE, 2011, France, *J Vasc Surg*[17] | 25 | n=150 (55.6 ± 6.6) [70.1 ± 7.1] | n=149 (55.2 ± 8.1) [68.9 ± 7.7] |
| DREAM, 2017, Netherlands, *J Vasc Surg*[18] | 30 | n=173 (60.0 ± 8.5) [69.5 ± 6.8] | n=178 (60.9 ± 9) [70.7 ± 6.6] |
| EVAR-1, 2016, UK, *Lancet*[19] | 37 | n=626 (62 [IQR 58-70])* [74 ± 6]* | n=626 (6.2 [IQR 5.8-7])* [74 ± 6]* |
| OVER, 2019, USA, *N Engl J Med*[20] | 42 | n=444 (57 ± 0.8) [69.6 ± 7.8] | n=437 (5.7 ± 1) [70.5 ± 7.8] |

### Outcomes in High-risk patients

To date there remains limited consensus on the optimum intervention for high-risk patients. The EVAR-2 trial aimed to establish if EVAR provided superior long-term outcomes compared to CM in patients deemed high-risk for OSR. Results reported reduced lower aneurysm-related but not all-cause mortality at 8-years post intervention.[21] This was attributed to high graft-related complications (48%) and re-intervention rates (48% and 27%, respectively), along with greater costs (£9,826 per patient; 95% CI, 7,638 – 12,013, per patient).[21] However, a French study reported more favourable outcomes following EVAR in high-risk patients. Specifically, reporting re-intervention rates of just 13%.[22] The authors attributed this to a superior method of risk stratification. Emphasising the importance of appropriate criteria when defining patients as

high-risk, they advocated for the French Agency of for the Safety of Health products (AFSSAPS) risk stratification tool (now ANSM), when selecting which patient should receive EVAR, as it considers a range of anatomical and physiological factors.[22] Another study proposed that development of new criteria is required for this patient group as they found that the AFSSAPS predicted neither postoperative mortality or complication rates accurately.[23]

A recent systematic review and meta-analysis investigated EVAR outcomes in high-risk AAA patients, comparing the results of 27 studies (6 single arm and 21 comparative studies).[24] 12 compared EVAR to OSR, 3 to CM and 8 to low-risk EVAR patients.[24] This paper highlighted a total of 16 different methods of defining high-risk. One study utilised cardiopulmonary exercise testing (CPET) variables as the defining criteria of high-risk.[24,25] Interestingly this study was one of the three that compared EVAR to conservative management and reported the greatest reduction in overall mortality and aneurysm-related mortality (adjusted and unadjusted) hazard for patients who received EVAR, compared to the other studies that used the EVAR 2 high-risk criteria, and a combination of age and comorbidity factors.[24,26,27]

Moreover, the meta-analysis revealed that just four studies achieved a 5-year follow-up period (Table 2) with more favourable outcomes in patients who were defined as high risk by CPET variables.[24] Providing support that the criteria for defining patients as high-risk may be a contributing factor in patient outcomes following intervention.

Table 2: Literature table providing comparison of 5-year survival rates between studies involving high-risk patients who received EVAR.

| Author | Sample (n) | 5-year survival | High-risk definition |
|---|---|---|---|
| Fisher *et al.* (2019), England, *Ann Vasc Surg*[25] | 37 | 81% | CPET – anaerobic threshold <11 ml/kg/min |
| Ramirez *et al.* (2019), USA, *J Vasc Surg*[28] | 325 | 60% | Hostile abdomen, >75 y, creatinine >2mg/dL or requiring haemodialysis, disabling COPD, HFrEF <25%, MI within the past 6 months |
| Greenhalgh *et al.* (2010), UK, *N Engl J Med*[21] | 197 | 30% | Hx of MI, cardiac revascular-isation, angina pectoris, heart valve disease, significant arrhythmia, uncontrolled CHF, FEV1 <1L, creatinine >2mg/dL. |
| Nagpal *et al.* (2007), *Canada, Vasc Endovasc Surg*[29] | 100 | 50% | ASA class 3 or 4, hostile abdomen |

Abbreviations: COPD=chronic obstructive pulmonary disease; HFpEF=heart failure with reduced ejection fraction; MI=myocardial infarction; CHF=congestive heart failure; FEV1=forced expiratory volume in 1 second; ASA=American society of anaesthesiologists

## CPET

Surgery induces a stress response causing increased metabolic demand, reduced cardiopulmonary reserve, heightened vulnerability to complications until homeostasis is restored.[30] Patients with insufficient metabolic and cardiopulmonary reserve may require life supporting interventions, such as supplementary oxygen, vasopressors, invasive ventilation, and dialysis.[31] Routine preoperative assessments now include investigations that evaluate a patient's physiology. The gold standard modality for this is CPET, which has been adopted as a risk stratification tool for patients undergoing major vascular surgery, including AAA repair.[16,32] Indeed, CPET variables have been identified as independent risk factors that reduce perioperative survival and adverse events.[33] Volume of oxygen consumption ($\dot{V}O_2$) <11ml/kg/min at the anaerobic threshold (AT) during CPET is associated with increased perioperative mortality in OSR.[33] Similarly patients with a $\dot{V}O_2$ at AT of <10.2ml/kg/min had increased 30-day mortality following elective AAA repair, in a prospective cohort study (n=415).[34] Moreover, peak oxygen consumption ($\dot{V}O_2$ Peak) which describes the highest value of oxygen consumption achieved during an exercise test,[35] has been found to increase 30 and 90-day mortality rates following AAA repair in patients who achieved <15ml/kg/min.[36] Additionally, ventilatory equivalents for carbon dioxide ($VE/\dot{V}CO_2$) of >42 at AT were found to increase 30 and 90-day mortality risk.[37] Evidently, multiple CPET variables are associated with worse perioperative outcomes, thus providing the basis for NICE to recommend CPET as the mainstay preoperative assessment tool, to ascertain if patients are suitable for elective OSR.[16]

Considering this, with the variety of risk-stratification methods used to define patients as high-risk, and the discrepancies in surgical practices and outcomes in this patient cohort, there is clearly a need for agreed consensus or the development of better methods of risk-

stratification, that should consider the ability of variables to predict long term outcomes, including survival and RfR, as it is these factors that remain contentiously debated in the literature.[22-25]

Pulse-pressure is the difference between systolic and diastolic blood pressure, representing the force exerted on the arterial walls following each left ventricular contraction.[38] High resting pulse-pressure indicates arterial stiffness or atherosclerotic disease, which are both risk factors for aneurysm development.[38-40] Moreover, pulse-pressure is reported as one of two independent variables that predicts thoracic aorta aneurysm formation and tight control of pulse pressure is reported to reduce endoleaks.[41,42] In healthy individuals', vasodilation of the peripheral blood vessels occurs during exercise, reducing peripheral vascular resistance, thus increasing blood supply to the working muscles which results in minimal change to diastolic blood pressure.[43] However, due to increased stroke volume, systolic blood pressure increases dramatically, collectively resulting in pulse-pressures of 80-100mmHg and >100mmHg in athletes.[44,45] Minimal increases or reductions in pulse-pressure indicate poor cardiac function.[38] Whilst pulse-pressure is not a commonly cited CPET parameter, considering its links to aneurysm development and cardiac function it may serve as a useful biomarker for preoperative assessment in patients with AAA.

To the authors knowledge, no studies have investigated whether CPET variables can predict long-term survival in high-risk patients undergoing AAA intervention or guide interventions stratification. As CPET variables have demonstrated the ability to predict short and long-term outcomes following AAA interventions, establishing which or if any can predict survival and RfR may aid in intervention stratification in patients deemed high-risk for OSR.[25,33,36,37] As objective measurements, CPET variables may also facilitate the ability to identify single numerical thresholds that provides practical cut offs for clinicians.

### Aims & Hypothesis

Primary aims of this study were to investigate the utility of CPET variables in predicting survival time and RfR in high-risk AAA patients following intervention, and to establish thresholds for CPET variables to enable clinicians and patients to select optimal intervention strategies in high-risk AAA patients. Furthermore, this study hypothesised that CPET variables are associated with and can predict survival time and requirement for re-intervention in high-risk AAA patients and in doing so can provide an insight for risk stratification.

## Methods

### Ethical approval

This single-centre retrospective study gained approval and was conducted in accordance with the ethical guidelines set forth by the Research Ethics Committee at University Hospitals Coventry and Warwickshire NHS Trust (GF0914) and Manchester Metropolitan University (Ethos ID: 67210).

### Study design

The study involved interrogation of a previously collected CPET database beginning in 2014 and terminating in January 2021. CPET data was obtained and analysed using BreezeSuite™ Cardiorespiratory Diagnostics Software. The database included patients with an AAA ≥5.5cm referred for preoperative assessment before intervention. Hospital electronic records were then interrogated, where mortality (all-cause and aneurysm-related) was recorded until the completion of data collection in January 2025. Intervention received was recorded and re-intervention outcomes were established for a minimum of 5 years following intervention. Inclusion criteria involved all patients with an AAA ≥5.5cm who were deemed high-risk for open-surgical repair (AT <11ml/kg/min) following a CPET within the department, with a 5-year minimum re-intervention follow-up period. Exclusion criteria involved patients who performed a CPET but were unable to achieve AT, incomplete data sets, patients with complex aneurysms requiring FEVAR, patients who underwent OSR or EVAR at a different hospital, and patients without a minimum of 5-year follow-up period. A total of 82 patients were enrolled onto the study (Figure 1).

The primary outcome measures were survival and RfR. Survival was established via hospital electronic records, RfR was established by interrogation of multi-disciplinary team meeting reports identifying one of the following: Endo

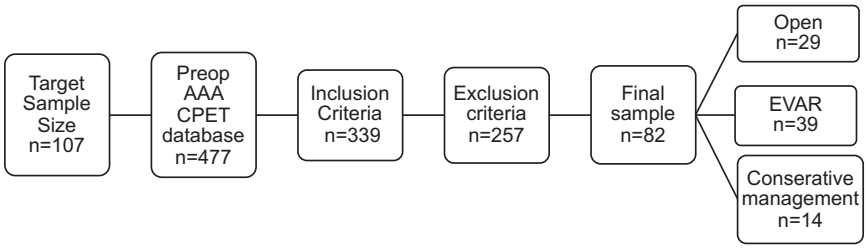


Figure 1. Schematic representation of stratified sampling resulting in a total of 82 patients enrolled onto the study. During the study period, 477 patients with an AAA were referred for preoperative CPET. 339 patients met the inclusion criteria. A total of 257 patients were excluded from the study resulting in a final sample of 82 patients.

leaks, ischaemia and surgical complications defined as requiring surgical or endovascular repair, regardless of whether the procedure was subsequently performed.

### Statistical analysis

Statistical analysis was performed using SPSS (IBM SPSS Statistics. Version 29.0.2.0 (20)). Descriptive statistics were computed for survival time distribution, demographics and CPET variables. Survival time for each intervention was tested for normality using the Kolmogorov-Smirov and skewness statistic. All 3 interventions were found to exhibit normal distribution. Survival time analysis (all-cause mortality) was conducted for each intervention using Kaplan-Meier curve to assess the probability of survival over time for each intervention. All patients that remained alive at the completion of data collection were censored. The log-rank test assessed for statistically significant differences between groups. 1, 3, and 5-year survival probability for each intervention was established at the intersection point between the y and x axis on the survival curve.

Multivariate Cox proportional hazards regression was performed to determine the relationship of different CPET variables and demographics on survival time and RfR. The significance level of $p<0.05$ was adopted. The Proportional hazard assumption was tested by a Schoenfeld Residuals Test. The Cox proportional hazard model's fit was established using the -2-log likelihood value following the Omnibus test of model coefficients. Hazard ratios (HR) with 95% CI were reported to quantify the direction and strength of the associations for each variable.

Receiver operating characteristic (ROC) analysis was performed to establish the performance of demographics and CPET variables found to be significantly associated with survival time or RfR, in predicting long-term survival (survival until the end of the study period), superior survival (survival greater than the upper 95%CI for CM) and RfR.

## Results

Comparison of demographic data (Table 3) indicated that patients who received CM were older and had a greater BMI. Mean AAA diameter was similar between groups. There was a high proportion of males in the sample making up 86.6% of the participants. Of the patients who

Table 3: Participant demographics, complications, and mortality rates for each intervention. AAA diameter, Age, BMI were established at the CPET performance date. Obstruction was defined by an $FEV_1/FVC$ ratio z-score ≤-1.64. Restriction was defined by an FVC z-score of ≤-1.64 (Sylvester *et al*., 2020). Maximal CPET criteria based on ARTP guidelines (Pritchard *et al*., 2021) criteria. Intervention complications, re-intervention, aneurysm-related, and all-cause mortality rates were followed up for a minimum of 4 years up to the end of the study period following intervention.

| Demographics | EVAR (n=39) | OSR (n=29) | CM (n=14) |
|---|---|---|---|
| AAA Diameter (SD) | 6.0cm (0.6) | 6.3cm (1.0) | 6.1cm (0.6) |
| Age (SD) | 73.9 (7.8) | 71.3 (8.0) | 77.4 (6.6) |
| BMI (SD) | 29.7 (5.2) | 27.2 (3.4) | 30.6 (4.4) |
| Sex | Female n=3 Male n=36 | Female n=7 Male n=22 | Female n=0 Male n=13 |
| Obstruction | 9 | 9 | 5 |
| Restriction | 2 | 3 | 1 |
| Achieved a max test | 23 (58%) | 14 (48%) | 7 (50%) |
| $\dot{V}O_2$ at AT (ml/kg/min) | 9.7 | 10.0 | 9.2 |
| Complications (rate) | 12 (30%) | 8 (27.5%) | N/A |
| Requirement for Re-intervention (rate) | 6 (15%) | 3 (10.3%) | N/A |
| Endoleak Type 1 | 2 | N/A | N/A |
| Endoleak Type 2 | 7 | N/A | N/A |
| Suitable for EVAR (%) | N/A | 7 (24.1%) | 2 (15.3%) |
| Aneurysm-related mortality (rate) | 1 (2.6%) | 1 (3.5%) | 2 (15.3%) |
| All-cause mortality (rate) | 11 (28.2%) | 10 (34.4%) | 10 (76.9%) |

received OSR, 75.9% had aneurysms that were not anatomically suitable for EVAR and 84.7% of patients receiving CM were not anatomically suitable for EVAR. Type 2 Endo leaks were more common than Type 1 (7 vs 2, respectively). Among the 82 patients, the all-cause mortality rate at 1, 3 and 5 years was 9.8%, 18.3%, and 28%, with 37.8% (31/82) of patients reaching mortality by the end of the study period. Aneurysm-related mortality was 4.9%.

### Statistical analysis

Mean survival time for each intervention (Figure 2) indicated a clinically meaningful greater survival of 359 and 1432 days for patients who received EVAR compared to OSR and CM, respectively.

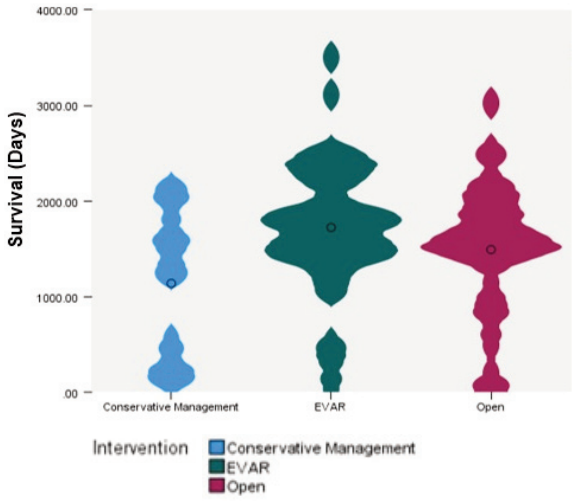


Figure 2. Violin plot depicting the density curves and mean survival across Intervention groups. The density curve for CM demonstrates a bimodal distribution with greatest density skewed toward lower survival, with a mean survival of 1138 days (95% CI: 678-1596). EVAR survival density curve demonstrates a multimodal distribution; however, the density is greatest around the mean, with a mean survival of 2570 (95% CI: 2130-3001). The density curve for OSR indicates the greatest frequency of data around the mean, with a mean survival of 2111 (95% CI: 1771-2652). CM n=14, EVAR n=39, OSR n=29). Log-rank Mantel-Cox test reported statistical significance between groups, represented by the number of asterisks; non-significant = ns; $p<0.05$ = *; $p<0.001$ = ***. Abbreviations: CM = conservative management; EVAR = endovascular aneurysm repair; OSR = open surgical repair.

Kaplan-Meier curve revealed greatest long term survival probability for EVAR compared to OSR and CM (Figure 3).

### The relationship between CPET variables and Survival

Multivariate Cox proportional hazards survival regression was performed to determine the

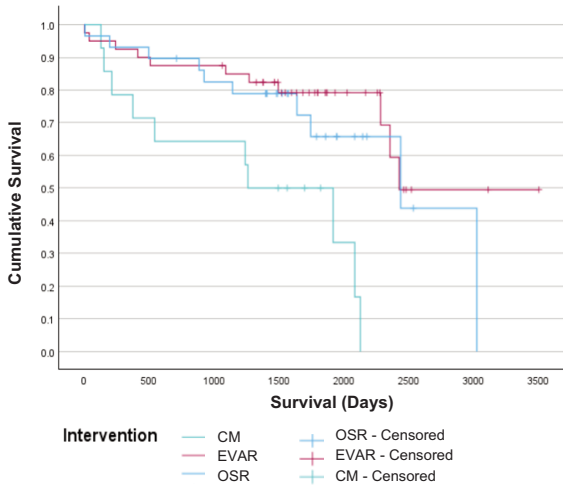


Figure 3. Kaplan-Meier curves representing survival grouped into intervention type.

effect of CPET parameters, and demographics on Survival time. Table 4 represents the final model. Two variables; $\dot{V}O_2$ Peak and Pulse-pressure at peak exercise (P-Pex) demonstrated significant associations with survival time. Both variables also demonstrated significant hazard ratios (HR: 0.668, 95%CI 0.489-0.911 and HR: 0.977, 95%CI 0.956-0.999, respectively), indicating a 33.2% reduction in mortality risk per 1ml/kg/min increase in $\dot{V}O_2$ Peak and a 2.5% reduced risk of mortality per 1mmHg increase in P-Pex.

### The relationship between demographics and EVAR re-intervention

Cox proportional hazards survival regression analysis was performed to determine the effect of CPET parameters, and demographics on RfR. Table 5 represents the final model. Only AAA diameter demonstrated a significant association with RfR. A hazard ratio of 5.19 (95%CI 1.158-23.246) indicated a significant increase in risk of RfR of 419% per 1cm increase in AAA diameter.

### Predicting outcomes

Receiver operating characteristics (ROC) were performed for variables found to significantly correlate with survival time (Figure 4A and 4B) and RfR. Thresholds were established for long-term survival prediction at 16.6ml/min/kg for $\dot{V}O_2$ Peak, with 33% sensitivity and 89% specificity, 91% positive predictive value and 92.5mmHg for P-Pex, with 59% sensitivity and 89% specificity, 94% positive predictive value. ROC curve for AAA diameter was found to be a poor predictor of RfR with an AUC of 0.64, therefore no thresholds were established.

Table 4: Multivariate Cox proportional hazards regression for survival. The model's fit was established using the -2 log likelihood value, reporting a strong model fit with a value of 106.40 and was confirmed by a significant Omnibus test of model coefficients (Chi-square); $X^2(5)=18.40$, p=0.002. The final model included $\dot{V}O_2$ at AT, $VE/\dot{V}O_2$ at AT, $\dot{V}O_2$ Peak, $O_2$ Pulse, and pulse-pressure at peak exercise (P-Pex). The Wald statistic identified that $\dot{V}O_2$ Peak (ml/min/kg) had the strongest association (6.265, p=0.012) with survival time, followed by P-Pex (4.371, p=0.37). All other variables in the model were not significantly associated with survival time. Hazard ratios for $\dot{V}O_2$ peak and P-Pex were 0.668 (95%CI; 0.489 -0.911) and 0.977 (95%CI; 0.956 – 0.999) respectively. Hazard ratios for all other covariates were not

| Covariates | Mean | Coefficient | Standard error | Wald | P value | HR | 95% CI | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| $\dot{V}O_2$ at AT | 9.6 (ml/kg/min) | .361 | .269 | 1.800 | .18 | 1.1435 | .847 | 2.433 |
| $VE/\dot{V}CO_2$ at AT | 39.8 | .041 | .037 | 1.192 | .27 | 1.041 | .968 | 1.120 |
| $\dot{V}O_2$ Peak | 14.6 (ml/kg/min) | -.404 | .159 | 6.467 | .011 | .668 | .489 | .911 |
| $O_2$ Pulse | 11.7 | -.110 | .129 | .724 | .39 | .896 | .695 | 1.154 |
| P-Pex | 88.7 (mmHg) | -.023 | .011 | 4.354 | .037 | .977 | .956 | .999 |

Table 5: Cox proportional hazards regression for requirement for re-intervention in the EVAR group. The model's fit was established using the -2 log likelihood value, reporting a strong model fit with a value of 24.02 and was confirmed by a significant Omnibus test of model coefficients (Chi-square); $X^2(2)=7.43$, p=0.024. The final model included AAA diameter and age. The Wald statistic identified that AAA diameter had the strongest association (4.632, p=0.031) with requirement for re-intervention. Age did not exhibit a significant association with requirement for re-intervention (2.651, p=0.1). Hazard ratios for AAA diameter and Age were 5.19 (95%CI; 1.158-23.246) and 0.103 (95%CI; 0.792 – 1.022) respectively. Hazard ratios for age were non-significant as the 95% CI included 1.

| Covariates | Mean | Coefficient | Standard error | Wald | P value | HR | 95% CI | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| AAA diameter | 5.9 (Cm) | 1.647 | .765 | 4.632 | .031 | 5.189 | 1.158 | 23.246 |
| Age | 73.4 (years) | .041 | .037 | 2.651 | .103 | .90 | .792 | 1.022 |

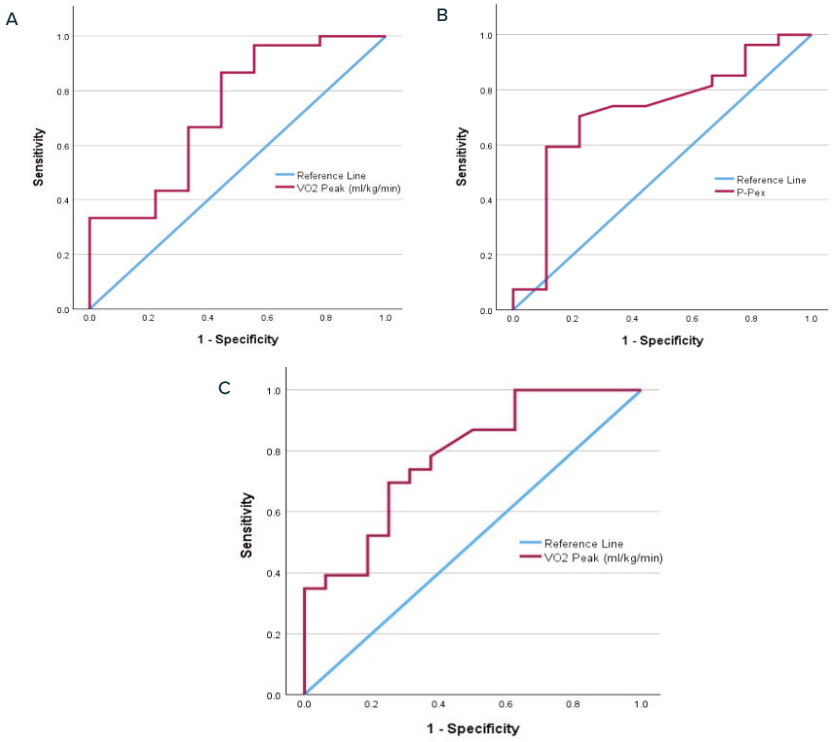


Figure 4. Receiver operating characteristic curves for covariates with significant associations with survival. A) ROC curve (AUC = 0.73) depicting the sensitivity and 1-specificity for $\dot{V}O_2$ Peak as a model of long-term survival prediction in the EVAR group (positive n=30, negative n=9). B) ROC curve (AUC = 0.72) depicting the sensitivity and 1-specificity for pulse pressure at peak exercise (P-Pex) as a model of long-term survival prediction in the EVAR group (positive n=30, negative n=9). C) ROC curve (AUC = 0.78) depicting the sensitivity and 1-specificity for $\dot{V}O_2$ Peak as a model of predicting superior survival (≥1567 days) in the EVAR group (positive n=23, negative n=16).

As EVAR was found to elicit a significantly greater survival time compared to CM, ROC curves were performed for $\dot{V}O_2$ Peak and P-Pex to predict superior survival following EVAR to aid in intervention selection. Superior survival was therefore defined as EVAR survival ≥1597 days, based on 1596 days being the upper 95% CI for CM survival. ROC curve (Figure 4C) for $\dot{V}O_2$ Peak demonstrated an AUC of 0.78 and a threshold was established at 14.5ml/kg/min with 70% sensitivity, 75% specificity and 80% positive predictive value. ROC curve for P-Pex was found to be a poor predictor of superior survival with an AUC of 0.63, therefore no thresholds were established.

## Discussion

This study aimed to investigate the ability of CPET variables to predict survival-time and RfR in high-risk AAA patients and to establish thresholds for CPET variables that would enable intervention stratification to maximise survival time.

### Intervention outcomes

Survival analysis demonstrated 79% 5-year survival for patients who received EVAR. Comparison of these results to the studies reported in Table 2 demonstrates the greatest 5-year survival probability in this cohort of patients, with results similar to that previously published by this institution.[25]

The evolution of EVAR grafts can be separated into four eras; physician-made grafts, early industry devices (1994-2003), intermediary commercial endografts (2003-2008), and current modern stent grafts.[46] A study compared the outcomes between each era, evaluating the impact of EVAR device evolution on numerous outcomes. Reporting improvements in procedural success, reduction in endoleaks, re-intervention, and perioperative mortality, as EVAR devices improved.[46] Similarly, this study utilised modern stent grafts and found reduced re-intervention rates at 6 years compared to the EVAR-2 trial (19% vs 27%, respectively) which utilised predominantly early industry devices.[12] Therefore, overall improvements in EVAR survival seen in this study and the literature may be attributed to the study period, with increased survival reported in more recent studies, in line with developments in graft quality. The evidence base that informs current NICE guidelines is primarily established from studies utilising early industry devices that may elicit outcomes inferior to that expected from today's modern devices. Therefore the current NICE guidelines may be outdated.

Interestingly, no significant difference was found between OSR and EVAR survival. However, a clinically meaningful improvement of 359 days was observed for EVAR. Moreover, inferior 5-year survival rates for OSR (66%) were reported, consistent with other studies of 67% and 69% in high-risk AAA patients.[47,48] Together, this supports the consensus that EVAR remains superior to OSR in high-risk AAA patients.

Mean EVAR survival was significantly greater than CM (1432 days, $p<0.001$). Despite this, 5-year survival rates for CM (50%) were far superior to that reported in the EVAR-2 trial (27%).[12] However, the results of the EVAR-2 trial utilised 8-year survival as the time point to define long-term survival, which the study period did not facilitate. In total, just 15.3% of CM patients were anatomically suitable for EVAR which may suggest that the group collectively had more complex aneurysms considering that OSR was mainly performed in patients who were also not suitable for EVAR (75.9%). This study did not aim to interrogate the collective decision-making of surgeons, anaesthetists and patients when selecting interventions. However, demographic and CPET data suggests that the perception of reduced fitness may have been a contributing factor, as CM patients were older, had increased BMI, and reduced $\dot{V}O_2$ at AT compared to the EVAR and OSR groups (Table 4).

### $\dot{V}O_2$ Peak

$\dot{V}O_2$ peak is a widely accepted measure of cardiopulmonary fitness, that holds significant prognostic and preoperative value.[32,49] In this study, higher $\dot{V}O_2$ peak was significantly associated with improved survival which supports the prior literature. Furthermore, reduced mortality hazard (HR: 0.668, 95% CI 0.489-0.911) was found, with fair predictive value for long-term survival (AUC=0.73) and superior survival (AUC=0.78) in patients who received EVAR, with thresholds of ≥16.6ml/kg/min and ≥14.5ml/kg/min, respectively. These findings align with Grant et al,[37] who found reduced 3-year survival rates following OSR or EVAR in AAA patient who did not achieve preoperative CPET thresholds of $\dot{V}O_2$ Peak ≥15ml/kg/min. $\dot{V}O_2$ Peak threshold of 14.5ml/kg/min for superior survival may serve as a useful preoperative biomarker to guide collective decision-making, regarding selection of optimal interventions in high-risk patients, as patients who do not achieve this threshold may live longer if they receive CM. This analysis however did not seek to establish the impacts of morbidity

associated with either intervention, or their effects on quality of life.

### $\dot{V}O_2$ at AT

$\dot{V}O_2$ at AT has been associated with 30-day mortality following elective AAA repair.[33,34,37] However, more recently Parkes *et al*,[50] found no relationship between $\dot{V}O_2$ at AT and perioperative EVAR outcomes (length of hospital stay and critical care requirements), suggesting that a reduced $\dot{V}O_2$ at AT may not be a useful marker for selecting which patients are suitable for EVAR. Similarly this study found no association between $\dot{V}O_2$ at AT and survival following EVAR. These results suggest that clinicians should interpret $\dot{V}O_2$ at AT with care when considering suitability for EVAR.

### Pulse-pressure

Considering the body of evidence relating pulse-pressure to aneurysm development and EVAR complications it was included in the analysis, primarily to investigate its role on RfR.[41,42] This study found no significant association between resting pulse-pressure and survival or RfR. However, pulse-pressure at peak exercise (P-Pex) demonstrated a significant positive association with survival, with a modest but significant reduction in mortality hazard (HR: 0.977, 95% CI 0.956-0.999). ROC curves demonstrated a fair predictive power for long-term survival (AUC=0.722) but poor predictive power for superior survival (AUC=0.63) in patients who received EVAR. A threshold was established at 92.5mmHg indicating that patients who achieved this value or greater had increased likelihood of long-term survival. Gupta *et al*,[51] found that an increase of <44mmHg (systolic blood pressure) during exercise testing was a significant independent predictor of mortality within 6 years in 6145 men. Therefore, the findings in this study that P-Pex of ≥92.5mmHg positively predicts long-term EVAR survival may reflect patients who possess the ability to meet the cardiac demands of maximal exercise, indicating sufficient cardiac reserve

### AAA Diameter

This study found a significant association between AAA diameter and RfR following EVAR. With a significant hazard ratio (5.189 p=0.031) indicating a 419% increased risk of RfR per 1 centimetre increase in AAA diameter. These findings are supported by a systematic review of the predictive factors associated with aneurysm-related complications following EVAR, which identified pre-operative AAA diameter as the most observed risk factor for re-intervention[52] However, ROC curve for AAA diameter as a predictor of RfR identified a poor AUC of 0.64. Unbalanced case processing may explain this, as only 6/39 patients required re-intervention. Certainly, larger sample size is required to investigate the role of CPET and demographic variables on RfR. However, the findings are consistent with the literature; delaying surgical intervention may itself be a risk for re-intervention as AAA diameter increases over time.

### Limitations

$\dot{V}O_2$ peak is generally interpreted as the maximal exercise capacity achieved that is limited by oxygen delivery to the exercising muscles. In reality, $\dot{V}O_2$ peak often reflects the patient's "best effort", with just 58% of patients that received EVAR achieving a maximal CPET as defined by ARTP guidelines.[53] Therefore, $\dot{V}O_2$ Peak may have been underestimated in 42% of patients, which may explain the false positives found in the ROC analysis. Despite these limitations however, $\dot{V}O_2$ Peak has been consistently linked to clinical outcomes after surgery.[49]

This small sample sized, single-centre, retro-spective study was somewhat underpowered. As a result, the findings may not be representative of other hospital trusts or patient populations.

## Conclusions

EVAR offered a survival advantage compared to OSR and CM. This is contrary to the EVAR-2 trial and summary of meta-analysis' that could be explained by modern techniques.[21,46] Indeed, the findings presented in addition to the literature consensus suggests that NICE[16] guidance for the management of AAA is outdated and does not reflect the progress in surgical practices and perioperative care made to date.

$\dot{V}O_2$ peak and P-Pex may serve as biomarkers that indicate poor likelihood of long-term survival following EVAR in patients achieving a $\dot{V}O_2$ Peak <16.6ml/kg/min or P-Pex <92mmHg. Furthermore, a threshold of ≥14.5ml/kg/min $\dot{V}O_2$ Peak may be used as a method to guide intervention stratification. $\dot{V}O_2$ at AT was found to be a poor marker of survival following intervention in this cohort of high-risk AAA patients, suggesting that it should be reserved for assessing suitability for OSR alone. AAA diameter plays an important role in RfR following EVAR and any delays in intervention resulting in aneurysm expansion may significantly increase the risk of graft-related complications and RfR. Further research with larger, ideally prospective studies is required to validate the thresholds established.

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# FRESH AIR

Edited by **Dr Samantha Irvine**
*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.

In this edition, we're thrilled to feature Mollie Riley, a Paediatric Respiratory Physiologist at Great Ormond Street Hospital (GOSH) and an active member of the research committee. Alongside her clinical work, Mollie—like many of her colleagues at GOSH—is pursuing a PhD. In her article, she takes us on a fascinating journey: from her early involvement in Cystic Fibrosis clinical trials to her current research on Multiple Breath Washout MBW. It's a candid look at what it's like to balance clinical responsibilities with the demands of a PhD, and it offers a unique window into the world of translational research.

## Mollie Riley – PhD Student and Respiratory Physiologist

I'm Mollie Riley, a paediatric respiratory physiologist at GOSH for children as well as current PhD student, recently awarded 'Best Respiratory Poster' at this year's ARTP Conference. I was invited to share an overview of my PhD research, together with my PhD journey and the realities of balancing doctoral life with working as a physiologist full-time. My project is in paediatric Multiple Breath Washout (MBW) and is focused on looking at developing under-utilised MBW indices to understand changes in gas mixing in healthy children and children with Cystic Fibrosis (CF) lung disease.

My journey into clinical research unfolded gradually and likely began with my final-year PTP dissertation project I carried out in 2017 (five years prior to registering for a PhD in 2022). I chose a project without any long-term intention, but it ended up being the exact test and disease group I would undertake my PhD research in. This is a reminder not to underestimate the important work you do as a student or junior, as even early projects can shape your career. It was a small project comparing the difference in functional residual capacity as measured by MBW and body plethysmography in children with CF seen in routine clinic visits. This work definitely increased my interest in MBW; I remember appreciating the wealth of information on ventilation distribution that could be gathered just from normal tidal breathing. This interest must have been noticed, as when I presented the project at the ARTP Conference in 2018, I also won best respiratory poster there, which was a great achievement in my first year as a junior physiologist.

At GOSH, we work with children with CF every day, so my desire to understand exactly how this condition affects the lungs only became stronger over time. Over the next four years, I worked in the clinical department and became involved in research as much as I could. This was mostly straightforward as the lung function unit at GOSH has a very strong research culture. Between 2019 and 2021, I was heavily involved in a feasibility study at GOSH on the modified hypoxic challenge test. I contributed significantly to the delivery of the study, data analysis and write up of the publications [1,2], which prepared me perfectly to apply for a part-time research physiologist role in late 2021. Since the end of 2021, I have been responsible for the delivery of

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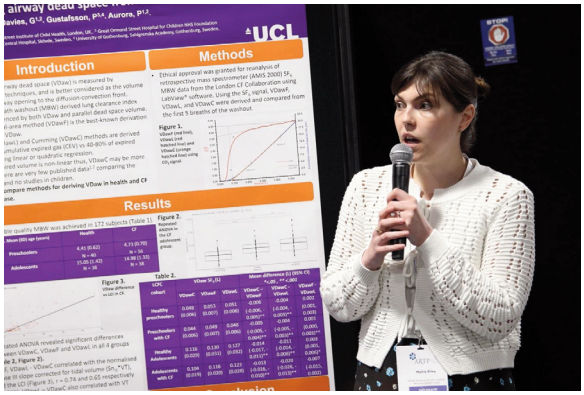


*Mollie presenting PhD work at ARTP Conference 2025*

the lung function outcome measures in a large, UK, CF registry trial. The CF START trial is a randomised registry trial to assess the safety and efficacy of Flucloxacillin as a long-term prophylaxis agent for infants with CF, led by Professor Kevin Southern. When the children are aged 3 and half years, families are invited to GOSH for MBW measurement. This project has brought so many of the areas I am passionate about together including MBW, translational research and the potential to make a real difference to CF patient care. Furthermore, the trial has given me the chance to pursue a PhD at UCL Institute of Child Health (ICH). Since May 2022, I have been registered for a part-time PhD, splitting my time between my usual duties in the clinical lung function unit and my role on the CF START trial.

As mentioned earlier, my project centres around MBW, a form of inert gas washout. MBW assesses ventilation inhomogeneity i.e., where some lung units are ventilated more than others by measuring the clearance rate of an inert marker gas e.g., Nitrogen from the lung during a 'washout'[3]. The LCI from MBW has become the 'go-to outcome' however, MBW offers many more outcomes beyond the LCI, many of which have not yet been investigated thoroughly. Potentially using other indices from MBW, alongside LCI will provide more insight into the diverse pathophysiology of CF as well as tell us about lung gas mixing in health and disease. In order to explore this new physiological ground that MBW can provide I have utilised the unique resources we have developed over the years at GOSH. We have collected very large datasets of MBW tests in patients with CF and healthy controls from infancy to adult age. Many of these datasets originate from the work of the London CF collaboration (LCFC), a research collaboration of paediatric CF centres, led by GOSH/ICH. Lung function measurements were performed at GOSH in two cohorts of children with CF and healthy controls. In fact, GOSH as the central hub for CF START testing was based on the LCFC model. These older datasets are particularly unique as they include MBW tests performed using the mass spectrometer, thus allowing for dual-gas (Sulphur Hexafluoride (SF6) and Helium) washout, which is unlike what is done with commercial devices today. The LCFC's findings focused only on the SF6 outcomes. This has provided an important opportunity within my PhD to revisit the data and report the dual-gas findings alongside other MBW outcomes including novel measures of dead space ventilation.

Also, through the work of the LCFC, our team has developed expertise in a MBW analysis method that is available in a limited number of specialist centres. This method is described as normalised phase III slope ($Sn_{III}$) analysis and is used to derive the following parameters: $S_{cond}$ and $S_{acin}$.[4] These indices can identify and separate the physiological mechanisms of ventilation inhomogeneity, which in turn may reflect structural changes within the lung. $S_{cond}$ has been shown to be a sensitive measure of early CF lung disease[5–7], meaning it may be highly useful for the future of CF care in this post-modulator era. However, its use remains limited as $Sn_{III}$ analysis is restricted to the research setting due to the demanding quality control required. My PhD project hopes to address some of these quality control aspects by exploring additional parameters with emphasis on improving integration into the clinical setting. I have also conducted a controlled study in healthy adults investigating the impact of breathing pattern on $Sn_{III}$ analysis, which may help inform and refine the $Sn_{III}$ analysis criteria.

Within my research team, I am very fortunate to be supervised by Dr Paul Aurora and Dr Gwyneth Davies at GOSH. I also have an external

## FRESH AIR

*Mollie working on her PhD at Dr Per Gustafsson's Swedish summer house*

supervisor, Dr Per Gustafsson who is based in Sweden. I have visited Per's summer house several times over the years, which has been a highlight; swimming in the Swedish fjords while chatting about all things physiology is a great PhD memory. Balancing all of my different working roles has been very challenging at times and means I have had to be super organised and prioritise certain tasks over others. However, doing my PhD at the same time as my clinical job has meant I have advanced in my clinical role, which I am grateful for. I have also learnt that the nature of my work ebbs and flows; some weeks I am more clinical and others I am focused on my research. Completing my PhD has come with sacrifices along the way; I often find myself writing on a Sunday afternoon. I hope to submit my thesis by the end of April, and I am very much looking forward to that milestone.

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# Lab in the Limelight

**Shirley Coelho**
*Lead Respiratory Physiologist*

## Respiratory and Sleep Physiology Wye Valley NHS Trust

*"If you build it, they will come" – Field of Dreams, (and they did!)*


### History and overview of the department

The Respiratory and Sleep Physiology Department at Wye Valley NHS Trust has undergone quite the transformation in recent years. What began as a small but mighty team of five clinical staff and some part-time admin support has grown into a thriving, twenty-strong department delivering a full range of diagnostic and therapeutic services across three sites: Hereford County Hospital, Hinton Community Centre, and the Community Diagnostic Centre (CDC).

Based in the heart of Herefordshire, our team provides a comprehensive respiratory and sleep service to patients across the county and to a significant portion of Powys. Despite being a smaller Trust, we punch well above our weight, offering everything from routine pulmonary function testing to complex sleep disorder diagnostics, and ventilatory support.

Our growth has been a true team effort, a mix of "build it and they will come", strategic visibility, and, if we're honest, a bit of well-timed "poaching." (All above board, of course).


## Lead Physiologist Background and Career – Shirley Coelho


I'm a Clinical Scientist and the Sleep Service Lead for Wye Valley NHS Trust. My career started in Portugal and, as is the case for many who came to the UK for "just a couple of years of experience", two years somehow turned into eleven.

Over the years, I've worked as a locum across eight different NHS Trusts, and I genuinely owe much of who I am as a clinician to those experiences. Each place taught me something new; about systems, patients and people, and gave me a panoramic view of how healthcare functions (and how it doesn't).

Joining Wye Valley felt like a natural next step: a smaller Trust where one person can make a tangible difference. Since arriving, my mission has been to grow the department into a well-oiled, forward-thinking service that delivers high-quality respiratory and sleep care across Herefordshire and beyond.

While sleep is technically my "main thing", I have a soft spot for all things respiratory and a particular fondness for a good CPET. Outside the Trust, I lecture part-time at Swansea University, where I was recently awarded a Fellowship of the Higher Education Academy (HEA). And because I don't seem to like a quiet life, I also serve as Lead Assessment Content Editor for Respiratory and Sleep Science at the NSHCS, contribute to the MRCP(UK) Specialty Question Group, assess equivalence portfolios for the AHCS, and maintain strong academic links with UWE Bristol, where I'm involved in consulting, teaching, and assessing.

## Meet the Team

Our team is a perfect blend of skill, passion, and personality, with a healthy dose of chaos that somehow always works itself into order.

We started small, but through persistence, working on visibility, and the occasional recruitment charm offensive, we've put together a dynamic and genuinely lovely bunch of people.

Michael Howard, now Head of Respiratory and Cardiac Physiology, quite literally built this lab from the ground up. Despite his promotion, he hasn't let the "power" go to his head, you'll still find him doing post runs, covering ventilation clinics, or lending a hand wherever needed. Leadership, done right.

Claire Francis, our Clinical Scientist, Respiratory Deputy, and all-round phenomenal human, cannot go unmentioned. She's the main reason I joined Hereford in the first place, and she continues to keep me on my toes daily. Chair of the ARTP Spirometry Committee, she has led our scientist-led respiratory clinics, written our most recent business case for direct GP referrals, and remains one of the sharpest professionals I know. My only wish? That she loved spreadsheets half as much as she loves everything else.

Alice Bonham-Carter joined us as a final year STP student and is now a fully-fledged Clinical Scientist, in the process of completing her ARTP CPET portfolio. Neurospicy, brilliantly creative, and endlessly surprising, she thrives on variety and has an uncanny ability to see solutions (and problems) the rest of us wouldn't notice.

*Left to Right: Alice Bonham-carter, Hannah Cullen, Deanna Conway, Claire Francis, Nikki Cooper-Tomkins, Vikki Simpson, Dan Horrocks, Shirley Coelho*

*Left to right: Dan Horrocks, Claire Francis, Mike Howard, Nikki Copper Tomkins, Leah Gould, Alice Bonham-Carter, Hannah Cullen, Shirley Coelho, Abi McKenzy, John Myles*

Then there's Hannah Cullen, who joined us after a bit of strategic "conference networking" and has since completed her ARTP Practitioner Certificate and PGCert in Sleep Medicine at UWE, both with distinction. She's the most organised person in a world of organised chaos and is now leading our challenge testing service for complex asthma patients. Her combination of competence and "fake calmness" has kept us all sane more times than I can count.

We also welcomed Leah Gould, who made the brave leap from ophthalmology to respiratory, proving that fresh eyes (pun intended) do bring fresh ideas. She's on her way to becoming an excellent physiologist and a core part of the team. She has completed a L4 apprenticeship, the ARTP spirometry performance and interpretation, the ARTP associate practitioner, and the ARTP oximetry portfolio. It is a great achievement that she has completed all these within three years of being with us and achieved a Distinction. At present she is conducting an audit on UARS and CPAP compliance, and working through our list of CPAP follow-up patients who haven't been in contact with the service for a while.

*Left to right: Nikki Cooper Tomkins, Hannah Cullen, Louise Peers, Alice Bonham-Carter, Leah Gould, Shirley Coelho, Claire Francis*

Dan Horrocks, is our psychologist who (by happy accident) has become a key part of our sleep service. With his CBT background and growing expertise in sleep medicine (also just finishing the PGcert in sleep medicine), he's helping us support our COMISA patients, primary insomnia, and circadian rhythm disorders. He designed the pathway and clinic layout, as well as the supporting documentation. There's even a relaxation recording by Dan, for the stimuli control phase of the programme. It works!

International recruitment also brought us Neena Pious, a respiratory therapist from India with experience in the acute setting. She embraced the outpatient world (she kind of had to!), completing her Associate Practitioner Certificate, Clinical Top-Up, and now enrolled on the PGCert in Sleep Medicine. Her adaptability is nothing short of motivating.

*Left to right: Emily Cornes, Abi McKenzy, Vince McNally MBE (Hinton Community Centre), Leah Gould, Shirley Coelho, Alice Bonham-Carter (front)*

Speaking of adaptability, Abi McKenzie and Nikki Cooper-Tomkins are two of our finest examples of seeing potential and nurturing it. Both began as admin staff, completed their Level 2 apprenticeships, and are now fully-fledged clinical team members. They keep our pulmonary function lists running smoothly, tackle CPAP troubleshooting, and support our consultants during 2WW clinics. Nikki has also completed her ARTP spirometry and interpretation certificate with a Merit, and the ARTP oximetry certification.

Emma Lowles, our sleep-only physiologist (and resident morale-booster), keeps the sleep service ticking like clockwork. She has an unmatched ability to make light of most situations. While we'll be sad to see her go as she heads into midwifery, we're certain she'll bring the same warmth and efficiency to her new role.

Our growing cohort also includes Salma Liaqat and John Myles, our two current STP students, along

with Sophie Elcox-Bond and Ailsa Driscoll, our new Associate Practitioners, both of whom are already showing the enthusiasm and standard we like to pride ourselves on at Hereford.

And last but never least, our admin dream team: Rasa, Emily, Deanna, Kiera, and Fran; the backbone of everything we do. They juggle schedules, manage (a lot of) short term changes of plan, and keep us all functional.

## What We've Achieved

If there's one thing we do well, it's saying "yes" first and figuring out the details later. And somehow, it's worked.

We've expanded our walk-in sleep clinic, piloted a CBT-I service, and streamlined our pre-op sleep screening pathway, reducing the average time from referral to treatment to just six days.

Our Community Diagnostic Centre (CDC) opened recently, equipped with shiny new kit that we're in the process of mastering.

To tackle long waits, we mixed outsourcing (this was short lived) with our own "extravaganza clinics" high-volume, high-energy sessions that brought our sleep disordered breathing RTT from over 32 weeks to under 8 weeks. Patients now receive results and CPAP setups within the week.

Even though our first Outpatient appointment and CPAP setup waiting lists are healthy, our CPAP follow-up list continues to grow. We try to ingrain in our patients the importance of self-management and we invest on patient education and information to take full advantage of Patient Initiated Follow Up (PIFU). We are also aware that PIFU doesn't fit every patients' needs and therefore we have a separate "CPAP surveillance" list with minimal waiting times, this covers DVLA patients, those we suspect CPAP may not quite do the trick, learning disability patients, etc.

Working with our respiratory consultants, we've improved the NIV pathway by introducing another acute weaning stage, helping inpatients adapt to domiciliary NIV before discharge and follow-up within two weeks and remote monitoring. Both "door-to-mask time" and "average length of stay" were reduced after the AVAPS-at-admission pilot.

Our scientist-led respiratory clinics have also taken off, allowing us to see more patients efficiently while maintaining quality. A consultant now reviews 4–5 patients per hour (MDT style) instead of one.

Behind the scenes, we've embedded a culture of learning, teaching, and doing. At one point, every single member of the department was undertaking some qualification or other. Between ARTP certifications, apprenticeships, STP training, PGCerts, and in-house development, we've built a team that's both highly skilled and continuously growing.

Our consultants kindly donate their DVLA form payments to a fund we use for training and conference attendance, a perfect example of our collaborative spirit in action.

## Future Directions & Developments

We're far from done. The next phase of our development will focus on re-auditing, publishing, and sharing our outcomes more widely. We plan to expand our behavioural sleep service (with particular focus on circadian rhythm disorders and COMISA), and to continue developing our scientist-led clinics across both respiratory and sleep.

We'll also be investing time in cross-training, ensuring every physiologist can cover across both specialities, keeping work varied, skills fresh, and the department resilient and appealing.

And, because we can't resist a challenge, we plan to explore new ways of working that integrate even more closely with primary care, respiratory physiotherapy, and respiratory nurses.

# ON THE BLOWER

Paul Burns
ARTP INSPIRE Editor

Lovemedical
Cardiopulmonary Diagnostics

**It's been a busy few months for Love Medical!**

First, the team said goodbye to Josh Holt, one of their valued sales representatives. Josh spent four years with Love Medical and is now taking a career break to travel the world. Good luck, Josh—we'll miss your karaoke performances at this year's conference!

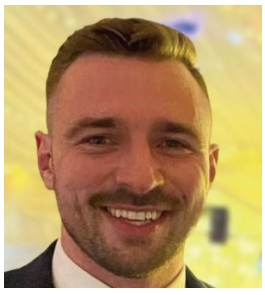
Over the past few months, Love Medical has supported several CPET courses with their equipment, including their own course in Manchester, the ARTP CPET course in Liverpool, and the Evidence-Based Perioperative Medicine (EBPOM) Global CPET course in London.

In September, the team headed to Amsterdam for the ERS Congress to connect with European partners and showcase their latest product developments. Managing Director Julian even found an excellent Irish bar for a large ARTP gathering—great work, Julian!

Finally, a huge congratulations to Finance Officer Harry Syson, who completed the Vichy Half Ironman in August in support of The Christie Charity. This Manchester-based charity provides enhanced services, equipment, and support for cancer patients—going above and beyond what the NHS typically funds. Well done, Harry!


## Jaeger Medical

JAEGER
Vyaire Respiratory Diagnostics is now Jaeger Medical



Jaeger has recruited Mark Porter as an account manager. Prior to this, Mark worked at the Brompton as a senior physiologist and completed the STP in the summer, so he brings a wealth of experience to the field. He will be an excellent addition to the team.

Vitalograph®

Vitalograph were proud to host the Future Readiness Industry Skills Lab at the recent ERS Congress, where experts from leading UK hospitals, Universities, and Vitalograph shared practical perspectives on shaping service delivery for the years ahead.


Adrian Fineberg, our EVP PFT Solutions was joined by Dr Karl Sylvester, Consultant Healthcare Scientist at Cambridge University Hospitals and Dr Rory Chan, Senior Clinical Lecturer at Dundee University and Consultant Respiratory Physician to discuss modern challenges for Respiratory Diagnostics services.

As Adrian summarised, the goal is to move as quickly as possible from presentation to diagnosis to treatment, delivering patient-centred care supported by actionable data. External expert partners – whether device or service providers – can offer fresh perspectives and tailored strategies to help departments escape historical siloes, upskill staff, validate quality, and make the case for investment in smarter, more flexible service models.

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# Getting to know your ARTP committee chairs


## Who am I?

I have worked in social and racial justice for many years. I am the Head of Inclusion-Improvement at University Hospitals Birmingham and worked for Birmingham City Council in organisational and leadership development before them.

My journey with respiratory health began when I met Max Thomas (ARTP Workforce Chair) and learned of my connection with this specialist area, having undergone a series of diagnostic tests for sleep apnoea over the last six years. This personal experience gave me firsthand insight into the critical role of respiratory technology and its impact on patients' lives. It fostered an appreciation for ARTP's work advancing respiratory care and technology.

I also had the benefit of delivering a presentation at your strategy day event focused on Equality, Diversity, and Inclusion (EDI), which gave me insight into the positive journey being taken and what value I could offer.

## A bit about me

I've always been fascinated by human behaviour, how our beliefs and thoughts are shaped, and how these, in turn, influence the people around us and the environments in which we work. As a dyslexic thinker, this curiosity runs even more profound.

My unique cognitive approach, often called my "superpower," allows me to excel in visualising, reasoning, and creative problem-solving. This non-typical way of thinking enhances my ability to empathise, lead with integrity, and truly listen, which is essential to fostering inclusive and equitable workplaces.

I have experience leading committees and programmes focusing on equity, diversity, and inclusion, and I have recently been the EDI theme lead for the NIHR Birmingham Biomedical Research Centre. I was also the EDI Leadership workstream lead for Birmingham and Solihull Integrated Care System's EDI Strategy.

On a personal note, I'm navigating the part-time "empty nest" phase of life with four adults who keep coming back - and a bike that's here to stay. Speaking of the bike, I've caught the cycling bug and can't get enough! By the time you read this, I'll have completed the London to Brighton ride, adding it to June's Wolverhampton to Aberdovey run, which was my longest ride yet.

## What would you like to achieve in your role?

Previously, I had the opportunity to be a board member of the Afro-Caribbean Millennium Centre, a grassroots community organisation, and Citysave Credit Union. Both of these organisations are dedicated to promoting equity and fair access, particularly in areas of race, class, and socioeconomics, which are causes close to my heart.

Bringing what I've learned from these experiences into this space where I can support and develop how ARTP works and, most importantly, impact the patients we serve.

# Introducing ARTP Board Members

## Asia Awal – ARTP Equality, Diversity & Inclusion Chair

### Who am I?

I am senior Clinical Physiologist/Clinical Scientist at Glenfield Hospital, UHL trust in Leicester. I started my career in 2013 as a student Respiratory and sleep Physiologist and worked at various respiratory physiology departments in Nuneaton, Derby and Burton before moving to my current place of work.

I also have a background in respiratory research working at the prestigious centre NIHR centre in Leicester. I enjoy working in fast pace environments and I have been very lucky to work with many inspirational people over the years.

### A bit about me

I am passionate about promoting, diversifying and expanding the workforce. I try to do this by attending local and national events to talk about Respiratory Physiology. I regularly assess spirometry portfolios and contribute to EPA assessments for the National School of Healthcare Science. I also strongly believe in promoting STEM as a female and encourage others to do so.

My main qualities are attention detail and adaptability. I like to review and consider information in making right decisions. I love having a chat with patient's, which means actively listening to patients and understanding them better.

Out of work I love hosting and entertaining parties and this root back to my background of being Bangladeshi. I am passionate about giving back to the community and work with local schools and charities.

### What would you like to achieve in your new role?

ARTP is a great organisation and have made some great, forward-thinking changes over the years. My role as the ED&I chair, I plan to support and develop our profession to ensure we promote inclusive culture and foster an environment where diversity is celebrated.

# Introducing New ARTP Committee Chair

## Dr Samantha Irving – ARTP Research Chair

### Who am I?

I'm a paediatric respiratory physiologist and postdoctoral researcher at the Royal Brompton in London, and I'm now the Chair of the ARTP Research Committee.

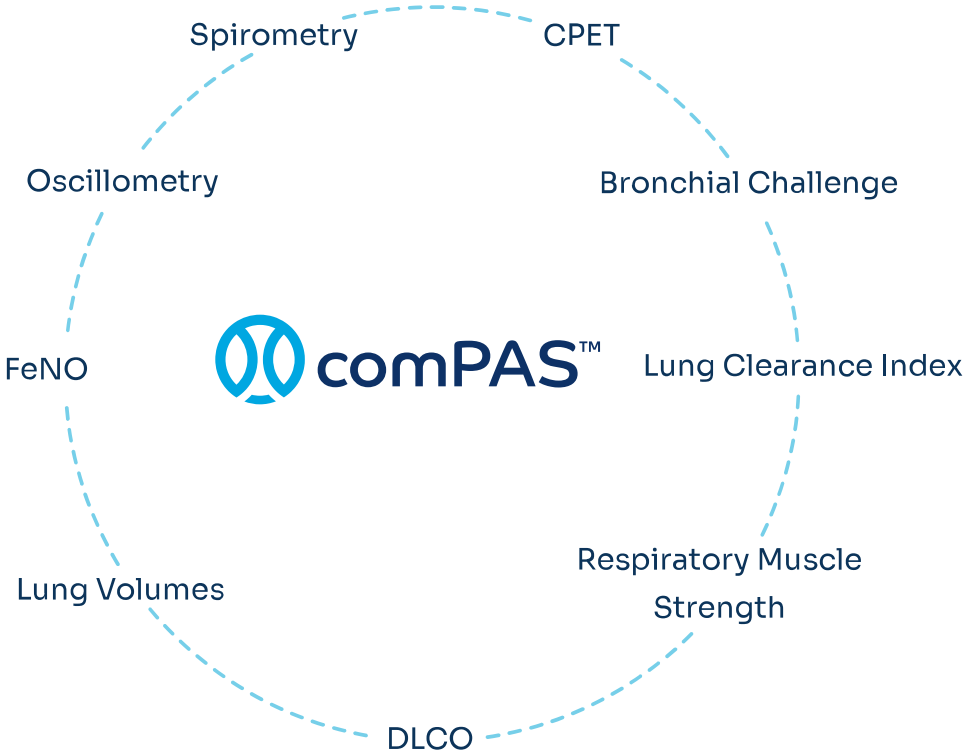
### A bit about me

I've been lucky to work and train in a research active clinical department, and I really enjoy the opportunity to do both sorts of work. I describe myself as a clinical academic as I can't imagine ever not having both these threads running through my work.

My specific research interest is the small airway in childhood respiratory disease, but I also love talking about and promoting careers with a research component for all sorts of healthcare scientists, but most of all for fellow respiratory physiologists!

I'm on a mission to make research a more visible component of all of our professional lives, and to get ARTP members leading on research up and down the country.

# Your respiratory diagnostics service is not just about testing, and neither is comPAS™

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# ARTP CONFERENCE 2025

## 1st–2nd May, Scottish Exhibition Centre, Glasgow

### ORAL PRESENTATIONS

### O1

#### Local Anaesthetic Administration Prior to CPET: A Safe Approach to Pain Reduction Without Compromising ABG Success

**Dr Maximillian Keech, Ms. Hannah Tighe, Mr. Craig Hunt, Mr. James Springett, Mr. Sam Faulkner, Ms. Jahida Begum, Professor Luke Howard, Dr Gulammehdi Haji**

*Imperial College Healthcare NHS Trust, London, United Kingdom*

**Introduction**: BTS guidelines recommend local anaesthetic (LA) should be used when performing arterial blood gas (ABG) procedures, outside of emergency situations, as it reduces pain for patients (O'Driscoll BR et al, Thorax. 2017 Jun;72).

While CPET is elective, it requires the ABG be taken at maximal exertion. Using LA increases the time taken to perform an ABG, so it cannot be administered at the end of CPET. Alternatives to ABGs that do not require LA include arterialised ear-lobe samples. However, these tend to underestimate PaO2 readings and are not recommended for use in CPET with patients with chronic lung disease (Radtke T et al, Eur Respir Rev. 2019 Dec 18;28(154)). Many LA agents have a duration of over one hour, which is longer than a standardised ramp CPET (Taylor A BJA Educ. 2020 Feb;20(2):34-41)

**Methods**: We devised a protocol to administer 1-2ml of 1% lidocaine subcutaneously over the radial artery prior to CPET initiation. This provides anaesthetic cover for the required ABG at the end of the test, giving pain relief as recommended by guidelines.

Data on administration of lidocaine was recorded and collected March to July 2024, including adverse events and success of ABG sampling. If more than one test had to be aborted due to adverse events from local anaesthetic, or a significant increase in ABG failure rate, the protocol would be abandoned. Differences in ABG success were analysed using fischer's exact test.

**Results**: 152 patients underwent CPET within the period. 91 patients had LA administered to protocol with no adverse events. 61 did not have, or declined LA. Those who had LA administered reported less pain from the ABG sampling. 87% ABGs were successful in those receiving LA, and 72% in those that had no LA (p 0.0343).

**Conclusions**: Administration of local anaesthetic prior to CPET is a safe and effective method for reducing pain from required ABGs. It may also reduce the failure rate of obtaining ABG samples (p 0.0343). We therefore propose this is a safe and effective method of reducing pain from ABGs required as part of a CPET testing protocol.

### O2

#### Evaluation of a Novel Clinical Scientist Led, One Stop Clinic for Unexplained Breathlessness

**Mr. Andrew Pritchard, Miss Megan Beacham, Dr Helen Ward**

*Royal Wolverhampton NHS Trust, Cannock, United Kingdom*

**Introduction**: Breathlessness is a frequent presentation in primary care, with a wide range of potential underlying causes. Delayed or inaccurate diagnosis can result in inadequate treatment and may lead to avoidable hospital admissions. Timely and precise diagnosis is essential to achieve optimal patient outcomes (NHSE 2023).

A novel diagnostic pathway was implemented within a community diagnostic centre (CDC) in the Black Country to address the needs of patients experiencing chronic breathlessness (>8 weeks). This initiative emphasises the role of the Clinical Scientist in triaging, diagnosing, and expediting care delivery within CDCs, providing a patient-centric approach while reducing demands on secondary care services.

**Methods**: Clinical scientists triage referred patients, selecting appropriate diagnostic tests tailored to individual needs. Diagnostic modalities include pulmonary function

| | |
|---|---|
| Referral total to date | 77 |
| Of which discharged to date | 66% |
| Age | 59.9 years |
| Sex | 43% Male |
| Require additional complex tests (CPET / HRCT / Mannitol etc) | 36% |
| Require onward referral into secondary care pathways | 6% |
| Conventional general respiratory clinic: requires follow up | 36% |
| Discharged with diagnosis | 92% |
| Discharged with primary pathophysiological cause (Asthma / COPD / ILD etc) | 57% |
| Discharged with primary psychosocial cause (Dysfunctional Breathing / Deconditioning / Anxiety / Depression etc) | 24% |
| This pathway: referral to clinic appointment (median) | 34 days |
| Conventional general respiratory clinic: referral to clinic appointment (median) | 157 days |
| This pathway: referral to discharge (median) | 71 days |
| Conventional general respiratory clinic: referral to discharge (median) | 188 days |

Table 1: Summary of Service Outcomes

# ARTP CONFERENCE 2025

## 1st–2nd May, Scottish Exhibition Centre, Glasgow

tests, bloods, chest X-ray, and ECG. Patients attend a single clinic appointment, where the Clinical Scientist conducts a detailed clinical history, performs the selected tests, and provides preliminary results. Clinics are CDC based to enhance accessibility and convenience for patients. Data was collected on pathway outcomes and compared to traditional secondary care pathways.

**Results**: Preliminary analysis shows that the novel pathway significantly reduces wait times, with a median referral-to-appointment time of 34 days and a referral-to-discharge time of 71 days. In contrast, the conventional general respiratory clinic pathway has a median referral-to-appointment time of 157 days and a referral-to-discharge time of 188 days, highlighting a marked improvement in service efficiency.

Patient feedback indicates that same-day test completion and immediate discussion of preliminary findings are key benefits of this approach. Furthermore, over 70% of patients were managed entirely within the CDC setting, reducing reliance on secondary care services. Importantly, only 6% of patients required a clinician-based follow-up appointment, compared to 36% in conventional respiratory clinics. This streamlined approach reduces diagnostic delays and facilitates timely intervention.

**Conclusion**: This pathway exemplifies the expanding role of Clinical Scientists in improving respiratory diagnostic services. By integrating clinical triage, diagnostic testing, and immediate feedback, this approach ensures timely and patient-focused care delivery. The favourable outcomes in diagnostic efficiency and accessibility underscore the value of Clinical Scientists in redefining patient pathways to meet contemporary healthcare demands.

### O4

### The influence of breathing frequency on the forced oscillation technique in patients with asthma

**Mrs Olga Carozzo, Dr Karl Sylvester, Dr Ben Knox-Brown**

*Respiratory physiology, Cambridge University Hospitals NHS, Cambridge, United Kingdom*

**Introduction**: Forced Oscillation Technique (FOT) is a non-invasive method to investigate the mechanical properties of the respiratory system, it works by superimposing pressure signals over normal tidal breathing. In a previous study, we found no significant difference in FOT parameters across multiple breathing frequencies (BF) in healthy young adults (Howlett-Foster et al 2022). However, it is unclear whether this is also true for patients with obstructive lung disease. This study aimed to assess if a change in BF would affect FOT measurements in patients with a confirmed diagnosis of asthma.

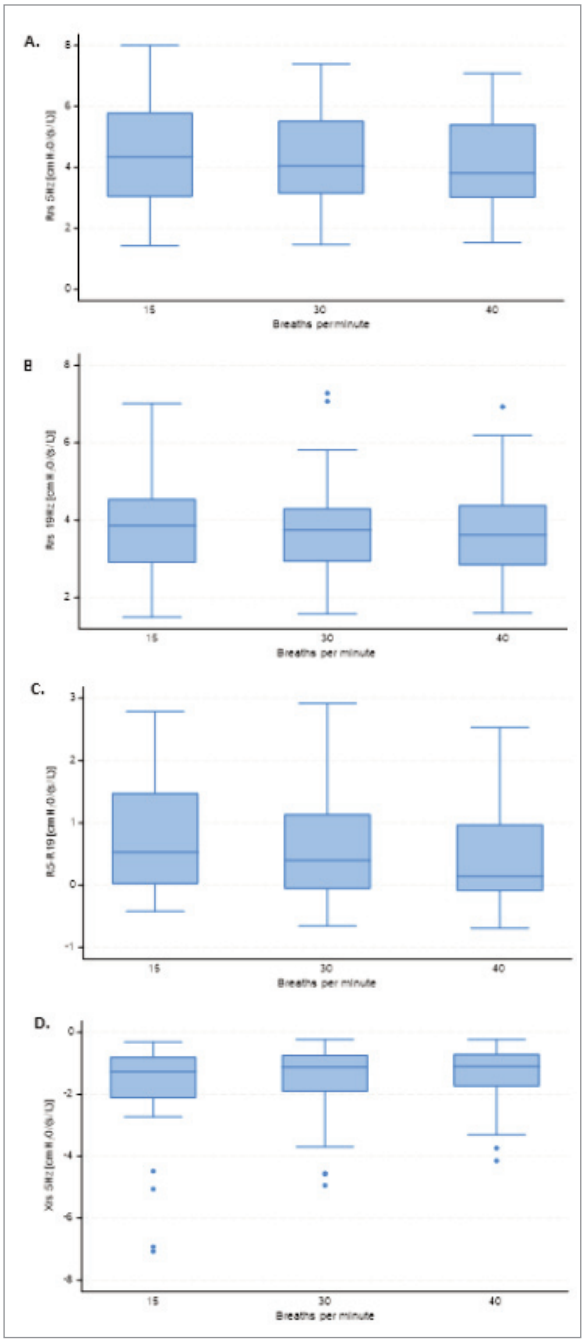


Figure 1. Box plot displaying (A) Change in Rrs at 5Hz at different breathing frequencies; (B) Change in Rrs at 19Hz at different breathing frequencies; (C) Change in R5-R19 at different breathing frequencies; and (D) Change in Xrs at 5Hz at different frequencies

**Methods**: We recruited patients with evidence of obstructive lung disease (FEV1/FVC<LLN) from the severe asthma clinic at Cambridge University Hospital NHS Trust. They performed FOT (Resmon Pro Full – Restech Srl) at 3 different BF (15, 30, 40 breath per minute) in a randomised order for each participant, with measurements at each BF performed in triplicate. A metronome was used to ensure the correct BF was achieved. For normally distributed data

# ARTP CONFERENCE 2025

## 1st–2nd May, Scottish Exhibition Centre, Glasgow

we performed ANOVA tests and for non-normally distributed data Friedman tests to assess the significance of any differences in FOT parameters across the BF.

**Results**: We recruited 59 patients. The mean age of the population was 54.1 years (13.4), 58% were female, the median FEV1/FVC ratio z-score was -2.56 (-3.26, -1.96). As BF increased, from 15 to 40 bpm, there was a significant reduction (-12%) in total airway resistance (R5) (P<0.001). There was also a significant reduction (-72%) in Delta (R5-R19) (P<0.001), and an increase (14%) in reactance (X5) (P=0.081) (Figure 1). At higher breathing frequencies, 5% of study participants were re-classified as normal compared to 15 bpm when using z-scores for R5 (>1.645).

**Conclusion**: Higher breathing frequencies significantly reduce total airway resistance, we recommend that when performing FOT, BF should be controlled at approximately 15 bpm to reduce risk of misclassification.

## POSTER ABSTRACTS

### P1

### Cutting Costs and Carbon: The Impact of Paperboard vs Plastic Spacers

**Miss Emily Spridgens**

*University Hospitals of Derby and Burton, Royal Derby Hospital, United Kingdom*

**Introduction**: Current practice in our Clinical Measurement Department is to use the Allen & Hanbury's Volumatic® spacer, a polycarbonate plastic device, during airway reversibility testing. The department is trialing the Clement Clarke DispozABLE® Spacer, which consists of a paper cup with plastic ends. This study compares their cost and theoretical carbon emissions.

Previous studies have compared performance of paperboard and valved chamber spacers. One study by Eynaud et al. (2024) found that paperboard spacers deliver a significantly higher dose of fine particles than less antistatic plastic chambers, ensuring optimal therapeutic effect.

**Methods**: Reversibility tests conducted from 01/01/2024 to 31/12/2024 were recorded, noting how many required spacers. The cost per spacer was obtained from the NHS supply chain and scaled to annual demand. Carbon emissions were estimated based on government conversion factors Department for (Energy Security & Net Zero, 2024), manufacturing location, spacer weight, incineration costs/emissions (NHS England, 2021), and recycling potential.

Although paper spacers are marketed as fully recyclable, local infection control policies require the plastic components to be disposed as offensive waste. For comparison simplicity, both spacers were assessed under offensive waste disposal.

**Results**

| | Volumatic | | DizposABLE | | Annual Savings |
|---|---|---|---|---|---|
| | Individual | Annual | Individual | Annual | |
| Spacer cost (£) | 4.65 | 1720.50 | 1.12 | 414.40 | 1306.10 |
| Spacer weight (kg) | 0.183 | 67.71 | 0.02 | 7.40 | 60.31 |
| Delivery transportation energy (Kwh) | | 1350.3 | | 771.6 | 578.7 |
| Incineration Carbon Emissions (CO2e/tonne) | | 1.44 | | 0.15 | 1.29 |
| Incineration cost yearly (£482/tonne) | | 32.64 | | 3.57 | 29.07 |
| Recycling Cost (£85/per tonne) | | 5.75 | | 0.63 | 5.12 |

Table 1: Comparison of plastic Volumatic spacers to the paper DispozABLE spacers. Conversion factors obtained from the Department for Energy Security & Net Zero (2024). Incineration costs to UHDB according to NHS England Waste Carbon Reduction Tool (2021).

**Conclusions**: Of 939 reversibility tests, 370 met requirements for bronchodilator administration and therefore required a spacer. Annually, £1,306 was saved by using paperboard spacers. Paperboard spacers reduced incineration carbon emissions by 1.299 CO2e/tonne and used 43% less transportation energy, as they are manufactured in England, unlike plastic spacers from Ireland. Additional benefits include reduced storage and packaging.

This small switch supports the NHS Net Zero by 2040 goal which aims for an 80% reduction in controlled emissions by 2028.

#### References

Department for Energy Security & Net Zero (2024), UK Government GHG Conversion Factors for Company Reporting
Eynaud et al (2024). International Journal of Pharmaceutics, 666, p.124774.
NHS England, Waste Carbon Reduction Tool (2021).

### P3

### The Early Respiratory Diagnostics Project Addressing a critical healthcare gap in the Armagh & Dungannon area

**Mrs Melissa Traynor, Mrs Lauren Smith**

*Armagh Dungannon GP Federation, Dungannon, United Kingdom*

**Introduction**: The Armagh & Dungannon Area falls within an area that is ranked 208/217 in the UK for Respiratory admissions and mortality (Asthma Lung UK, 2023). Currently, spirometry services in primary care (PC) is sporadic and conducted by practice nurses. Spirometry services were suspended during COVID-19 due to infection control concerns and now equipment has become obsolete and nurses deskille. It is also unfunded

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and not part of the GP GMS contract, making restarting services unattractive. There is also no direct GP access to investigations in secondary care, where waiting lists are 90 weeks for lung function and 5 years for routine consultants' appointment. This has lead to long waiting lists in PC, delayed diagnosis and substandard care.

**Methods**: A mobile advanced lung function service, led by a respiratory physiologist, that serves 22 GP practices in the Armagh Dungannon Area. The service offers x12 quality assured lung function appointments per week to include carbon monoxide transfer factor. Research indicates that 37% of patients with normal spirometry can have abnormal lung function, thus being missed at first point of contact (Sylvester et al, BMJ 2021). Practices also have access to FeNO using a cluster model with 8 machines being shared between 22 practices. Mentorship is also a key objective in reskilling nurses. Continuous auditing and feedback from patients and GPs to ensurec ontinous improvement.

**Results**: At 8months, 216 patients seen, 6.3% DNA rate, average wait time 8 weeks. 83 (38.4%) Normal lung function, 37 (17.1%) new asthma diagnosis, 39 (18%) chronic AFO, 17 other (7.5%), 40 (19%) require more testing in PC. 83 transfer factors performed - 17 (20.5%) abnormal.

170 FeNO performed in mobile hub, 46 (27%) abnormal (>25ppb). 54% of Asthma diagnosis could have been made with FeNO alone. (BTS, NICE, SIGN, 2024). 35% of patients with a definitive diagnosis and treated promptly in PC. Only 7.8% of cohort referred to secondary care for further investigation.

**Conclusion**: This service provides accessible, high-quality services to a rural community experiencing health inequalities. Implementing advanced tests in primary care settings is transforming patient care, ensuring timely and accurate diagnosis and better patient outcomes while reducing unnecessary referrals into secondary care.

### P4

### A retrospective analysis of the 'Lung Health Check': A community-based targeted lung cancer screening pilot performed in Doncaster.

**Miss Isobel Briggs, Miss Emily Cannadine, Dr Moe Kyi**

*Doncaster Royal Infirmary, Doncaster, United Kingdom*

**Introduction**: Lung cancer is the leading cause of cancer-related deaths in the United Kingdom (UK), with cigarette smoking identified as a primary risk factor for this disease (Bray et al. CA 2024). Once symptoms of lung cancer present, they are often non-specific and associated with advanced disease. As a result, this reduces the curative treatment options available to a patient, leading to a poor survival rate. It remains unclear if a UK lung cancer screening tool will lead to an earlier stage of lung cancer at time of diagnosis, increased lung function and therefore improved treatment options for patients. The aim of this study is to bridge this gap.

**Methods**: The 'Lung Health Check' (LHC) is a screening programme performed in the Doncaster area whereby current or ex-smokers, aged 55–74years, are screened for lung cancer. This retrospective study involved collecting data from March 2021-2023 which included 184 patients at Doncaster Royal Infirmary. 102 patients were identified through the LHC, and 82 patients were symptomatic and presented at their General Practice. Inclusion criteria involved patients aged 55-74 years, with no restriction on gender or existing lung conditions. Exclusion criteria included incidental findings of lung cancer. The following information was recorded: age, sex, smoking status, lung function test values, specifically FEV1 and TLCO %predicted, stage of lung cancer and planned treatments.

**Results**: An independent t-test showed significantly higher lung function values of FEV1 and TLCO at %predicted for the LHC patients p<0.001 specifically 11.1% and 11.4%, respectively. Two independent chi-square tests examined the association between the stages of lung cancer and planned treatment for the LHC and the symptomatic groups. This showed statistically significant results p<0.001 in both tests (Table 1). Statistical analysis was conducted via SPSS.

| Characteristics | LHC patients | Symptomatic patients |
|---|---|---|
| Age in years (mean ± SD) | 68.2 ± 5.0 | 67.1 ± 5.5 |
| Gender (M/F) | 44/58 | 35/47 |
| Current smoker | 41 | 42 |
| Ex smoker | 61 | 36 |
| Never smoked | 0 | 4 |
| FEV1 (%predicted) (mean ± SD) | 87 ± 20.7* | 76 ± 23.6* |
| TLCO (%predicted) (mean ± SD) | 73.7 ± 19.5* | 62.3 ± 21.2* |
| Percentage of patients with stage 1 lung cancer | 71% | 27% |
| Percentage of patients with stage 2 lung cancer | 12% | 6% |
| Percentage of patients with stage 3 lung cancer | 10% | 28% |
| Percentage of patients with stage 4 lung cancer | 7% | 39% |
| Percentage of patients with surgery as a planned treatment | 71% | 27% |
| Percentage of patients with radiotherapy as a planned treatment | 16% | 12% |
| Percentage of patients with chemotherapy as a planned treatment | 6% | 22% |
| Percentage of patients with chemoradiotherapy as a planned treatment | 3% | 13% |
| Percentage of patients with no active treatment planned | 0% | 1% |
| Percentage of patients with immunology as a planned treatment | 0% | 2% |
| Percentage of patients with specialist palliative care as a planned treatment | 4% | 23% |
| Total number of patients | 102 | 82 |

Table 1: Baseline characteristics *denotes statistical significance via an independent t-test p<0.001 between groups. Two independent chi-square tests examined the association between the stages of lung cancer and planned treatment for the LHC and the symptomatic groups. This showed statistically significant results p<0.001 in both tests

**Conclusions**: These findings demonstrate, screening at risk patients of lung cancer in the community leads to more curative treatments, lower stage of lung cancer and increased lung function, which could reduce a patient's morality. We therefore, strongly support the continued use of the LHC in Doncaster and implementation of this nationwide. We recognise a need to increase the workforce, to meet this demand.

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### P5

### Evaluating Attendance Rates for NHS Lothian's Respiratory Physiology Service and Using the Scottish Index of Multiple Deprivation to Improve Accessibility

**Miss Laura Van Ransbeke**

*NHS Lothian, Edinburgh, United Kingdom*

**Introduction**: NHS Lothian outlines a target DNA (did not attend) rate of 6% for all outpatient services across the Trust. Missed appointments have a detrimental effect on waiting list times, delaying access to diagnostic services and treatment. An NHS Lothian study suggests the average cost of a missed outpatient appointment is £30 (Lothian NHS Board 2024).

The aim of this service audit was to identify themes that may be driving DNA rates amongst patients referred to the Respiratory Physiology Service (RPH) by their GP. The Scottish Index of Multiple Deprivation (SIMD) was used to identify potential barriers to attendance, and defines deprivation by seven key markers; income, employment, health, geographical access, crime, and housing. It is hoped this audit will allow us to identify areas within the health board that have inequitable access to the service and improve attendance rates.

**Methods**: The SIMD was used to identify the 'most deprived 20%' (MD20) zones across Edinburgh and the Lothians. NHS GP practices located within these areas were then highlighted as such. Attendance figures from April 2023 to March 2024 were collected, providing data by GP practice and council area for each hospital site (Royal Infirmary of Edinburgh, Western General Hospital, and St John's Hospital).

**Results**: Over the 12-month period, 6,315 RPH appointments were scheduled following a direct referral from primary care, of which 23.4% were not attended. 14% of the 119 GP practices included in this audit are in a MD20 area. Referrals from these practices accounted for almost a quarter of missed appointments.

**Conclusion**: Data evaluation is still ongoing, however is so far proving useful in raising suggestions for reducing DNA rates. Based on the information that has been considered to date, a) improving the accessibility of appointment and pre-test information and b) increasing the availability of high-quality spirometry in primary care, reducing the number of patients required to attend the hospital outpatient department, would be sensible recommendations. It is hoped a repeat audit can be conducted once service changes have been approved and implemented to assess the efficacy of improvements.

#### References

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### P6

### The Impact of Peak Expiratory Flow Variability on the Forced Expiratory Volume in 1 Second

**Mr. Abdul-Rasaq Yakubu, Mr. Jake Williams, Dr Benjamin Knox-Brown, Mr. Joshua Barnes, Dr Karl Sylvester**

*Royal Papworth Hospital NHS Ft, Cambridge, United Kingdom*

**Introduction**: Current ARTP guidelines recommend that Peak Expiratory Flow (PEF) variability between manoeuvres should be within 40 L.min-1 for acceptability. However, this is largely based on a study by Pederson et al. (1996) which mostly included healthy individuals. Moreover, the original study was not designed to inform spirometry guidelines, and no formal evidence defines an acceptable level of PEF variation. Therefore, this study aims to explore the impact of variable PEF on the reproducibility of FEV1 in a cohort with diverse respiratory conditions.

**Methodology**: We analysed 22,071 spirometry manoeuvres from 4,913 patients (55% male; median age 64 [53-74] 92% Caucasian) tested at Royal Papworth Hospital NHS FT in 2023. To assess the impact of PEF variability on FEV1, manoeuvres performed during the same session and compliant with ATS/ERS 2017 standards were compared to a reference manoeuvre with the highest PEF. Data distribution was evaluated using

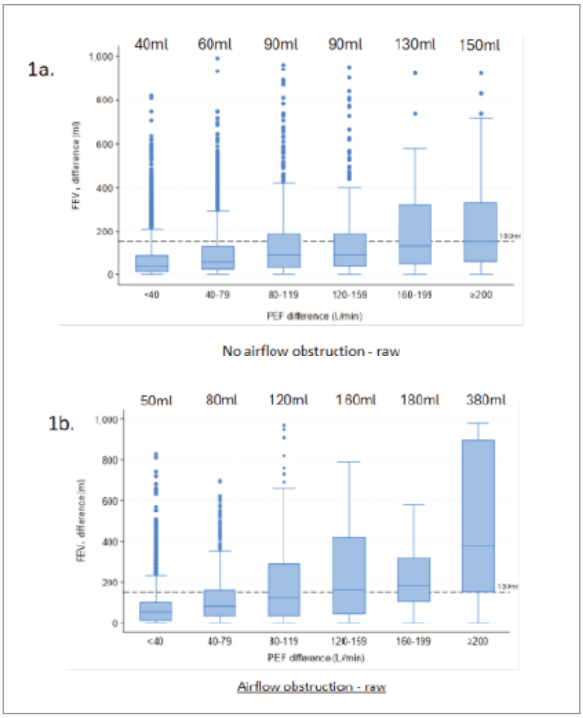


Figure 1. Compares the effect of PEF difference on $FEV_1$ in both obstructed and non-obstructed patients. The median values are reflected on top of each boxplot

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histograms, and the effects of PEF variation on FEV1 were visualised with box plots. Patients were stratified into those with airflow obstruction (FEV1/FVC < LLN) and those without (FEV1/FVC ≥ LLN). FEV1 difference (ml) was calculated across five PEF categories, (< 40 L.min-1 to > 200 L.min-1) and compared using the Friedman test.

**Results**: There was a significant difference in FEV1 across all PEF categories ($p < 0.001$), with FEV1 increasing as PEF difference increased. This trend was more pronounced in obstructed patients (Figure 1).

**Conclusion**: This study demonstrates that PEF reproducibility is directly related to FEV1 reproducibility, especially in patients with airflow obstruction. Our results support the current ARTP criteria that the PEF of acceptable spirometry manoeuvres should be within 40 L.min-1 of each other. Larger variation can result in over 25% of manoeuvres having an FEV1 difference >150 ml. Further research is required to determine the effect on disease severity and classification.

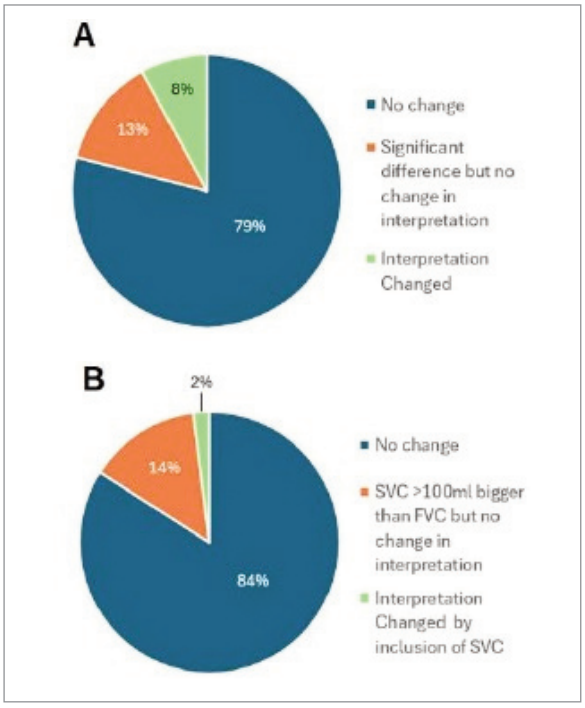


Figure 1. Pie charts summarising (A) the clinical impact of additional spirometry attempts after the first technically acceptable result is obtained and (B) the influence of SVC on clinical interpretation.

### P7

### Is one spirometry attempt sufficient for pre-operative assessment?

**Dr James Stockley, Miss Abigail Nock, Prof Brendan Cooper**

*University Hospitals Birmingham, Birmingham, United Kingdom*

**Introduction:** With an ever-increasing workload, physiologists can spend long periods completing a series of pre-operative assessments across many wards. We sought to determine if one technically acceptable spirometry attempt was sufficient (particularly if the result was normal) as a potential time-saving strategy.

**Methods**: We conducted a retrospective audit of 129 pre-operative assessments over a 12-month period. We gathered data on the number of attempts within each spirometry session, the attempt at which the first technically acceptable result was obtained, and achievement of ARTP reproducibility criteria (Sylvester et al. BMJORR 2020;7: e000575). $FEV_1$, FVC, $FEV_1$/FVC, and PEF were recorded (absolute value and z-scores) for each acceptable attempt and compared to determine if subsequent attempts after the first acceptable result affected the clinical interpretation. As a secondary outcome, SVC was assessed to determine if its inclusion also influenced clinical interpretation.

**Results**: Patients were 97M:32F, mean age 61 (range 20-90). On completion of the spirometry session, 59.7% had normal spirometry, 27.1% had a restrictive picture, 10.9% had airflow obstruction, and 1.6% were mixed obstructive/restrictive (Quanjer et al. ERJ 2012;40:1324-43). 16% performed only 3 attempts, 16% 4 attempts, 22% 5 attempts, 12% 6 attempts, 7% 7 attempts, and 27% completed 8 attempts. 54% of patients achieved a technically acceptable result on the first attempt. ARTP reproducibility criteria were met in 51% of cases.

Additional attempts after the first technically acceptable one were no different in 79% of cases. In 14%, subsequent attempts were significantly better (>100ml) but did not alter interpretation, and in 8% interpretation changed with subsequent attempts (Figure 1A). SVC was within 100ml of FVC in 84% of cases and did not influence interpretation. In 14%, SVC was >100ml larger but still did not alter interpretation, and in 2% SVC was larger and did impact interpretation (Figure 1B).

**Conclusions**: One technically acceptable forced spirometry may be sufficient for pre-operative assessment if normal, although it may not accurate enough for subsequent monitoring. SVC does not add value in almost all cases. If technically acceptable spirometry is abnormal, subsequent attempts are still recommended and, if these remain abnormal, SVC may then be useful.

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### P8

#### Simplifying Spirometry: Is one effort enough to rule out obstructive impairment?

**Mr. Rhys Tudge[1,2], Mr. David Yabar[2], Mr. Benoit Cuyvers[3], Dr Sanja Stanojevic[2]**

*[1]Manchester University NHS Foundation Trust, Manchester, United Kingdom, [2]Community Health & Epidemiology, Dalhousie University, Halifax, Canada, 3Clario, Leuven, Belgium*

Technically acceptable and repeatable spirometric measures are crucial for accurate pulmonary function test (PFT) interpretation. Artificial intelligence (AI) enables automated quality assessment, indicating reliable measurements in real-time. This study investigated whether the first AI-acceptable spirometry trial can rule out obstructive impairment.

Spirometry data (ndd Easy-on PC) from the Canadian Longitudinal Study of Aging (CLSA), a national prospective cohort of adults aged 45-85, were analysed using ArtiQ. QC software. All trials were assessed using 2019 American Thoracic Society/European Respiratory Society standards.

The first acceptable trial (where both forced expiratory volume in one second – FEV1, and Forced Vital Capacity – FVC, were acceptable) and the best acceptable trial (FEV1 and FVC acceptable with the highest values) after at least two acceptable and repeatable trials were compared for the FEV1, FVC, and FEV1/FVC ratio using Bland-Altman plots. Race-neutral Global Lung Function Initiative (GLI) lower limits of normal (LLN) were used to classify impairment (i.e., 5th centile).

Of 21,795 participants, 6,722 were excluded due to unacceptable data, leaving 15,073 for analysis. Small differences were observed between the first and best trials (mean difference in FEV1: 0.049 L [95% CI: 0.049, 0.051]; FVC: 0.053 L [95% CI: 0.052, 0.054]; FEV1/FVC: 0.0024 [95% CI: 0.002, 0.003]). Strong agreement was found between the first and best trials in ruling out obstructive impairments (99.7% sensitivity). However, the first trial falsely classified 16.6% as obstructed, highlighting potential challenges in diagnostic accuracy when relying solely on the first trial. A simplified protocol to rule out obstructive impairment could reduce testing time from 15 to 5 minutes, reducing testing time by 30% and saving an estimated 40 hours monthly.

The first acceptable spirometry trial offers potential as a screening tool to rule out obstructive impairment, whereas full spirometry assessment is necessary to confirm obstructive impairment. To minimize error, a higher LLN (e.g. 10th centile) could be used to prevent false negatives.

### P9

#### Impulse Oscillometry - The future in post lung transplant monitoring

**Miss Holly Le Winton, Syed Tousheed, Dr Ben Knox-Brown, Miss Wendy Sherman, Dr Karl Sylvester**

*Royal Papworth Hospital, Cambridge, United Kingdom*

**Purpose**: Lung transplant (LTX) recipients at Royal Papworth Hospital are routinely followed-up with lung function and chest X-ray. Acute cellular rejection (ACR) is a major complication, which is currently a significant risk factor for chronic lung allograft dysfunction. ACR is generally identified by routine monitoring with spirometry, however, impulse oscillometery (IOS) may provide a more detailed assessment of lung function, independent of patient effort. This study aimed to investigate the association between IOS and spirometry parameters cross-sectionally and longitudinally, with particular focus on those with a clinically significant decline in FEV1.

**Methods**: All post LTX patients attending for routine monitoring of spirometry between the 1st of December 2023 and the 1st of October 2024, performed IOS. Analyses were performed to investigate the correlation between IOS parameters and FEV1 at baseline, and longitudinally thereafter. Furthermore, the differences in IOS parameters among those patients who did vs did not have a 10% decline in FEV1 during the follow-up period were compared by Mann Whitney-u test.

**Results**: The LTX cohort consisted of 213 patients (female 38%, median age 57). IOS parameters correlated most strongly with FEV1, of which moderate correlations were demonstrated for R5-R20, X5 and AX ($r = -0.57$, 0.65 and -0.59 respectively $p<0.001$). In total, 93 patients had at-least one follow-up IOS and spirometry during the study. A moderate correlation was observed between change in FEV1 and change in R5, X5, AX and R5-R20 over time ($r = -0.49$, 0.60, -0.68 and -0.66 respectively $p<0.001$). All IOS parameters except for R20, were significantly more impaired among those with a 10% decline in FEV1, compared to those who did not have a 10% decline in FEV1 during the follow-up period.

**Conclusion**: IOS parameters indicative of small airways changes (R5-R20%, X5 and AX) are correlated with FEV1 both cross-sectionally and with respect to change over time. This highlights the potential benefit of using IOS alongside standard spirometric measurements in this patient cohort, to detect early changes and aid in earlier intervention.

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### P10

### Does closing volume measured by Forced Oscillation Technique reflect airway closure and gas trapping in comparison to Whole Body Plethysmography?

**Miss Ella O'Neill[1], Dr Karl Peter Sylvester[2], Dr Jonathan Fuld[3]**

*[1]Respiratory Physiology, Cambridge University Hospitals, Cambridge, United Kingdom, [2]Respiratory Physiology, Royal Papworth Hospital, Cambridge, United Kingdom, [3]Respiratory Medicine, Cambridge University Hospitals, Cambridge, United Kingdom*

**Background**: Chronic Obstructive Pulmonary Disease (COPD) is a condition characterised by lung inflammation, and lung tissue damage which causes airway obstruction making it challenging to breathe (Pauwels et al., 2001). Symptoms such as an increased sensation of breathlessness and reduced exercise capacity can be caused by a decreased elasticity of the lungs, and early airway closure causes gas trapping within the lungs (Sindh et al., 2019). The primary method of assessing gas trapping is body plethysmography, however some patients struggle in performing elements of the test, making the results inaccurate.

**Aim**: The aim of this research is to highlight the utilisation of new technology, identifying if using the forced oscillation technique to determine closing volume (CVFOT) can be used as an assessment of gas trapping.

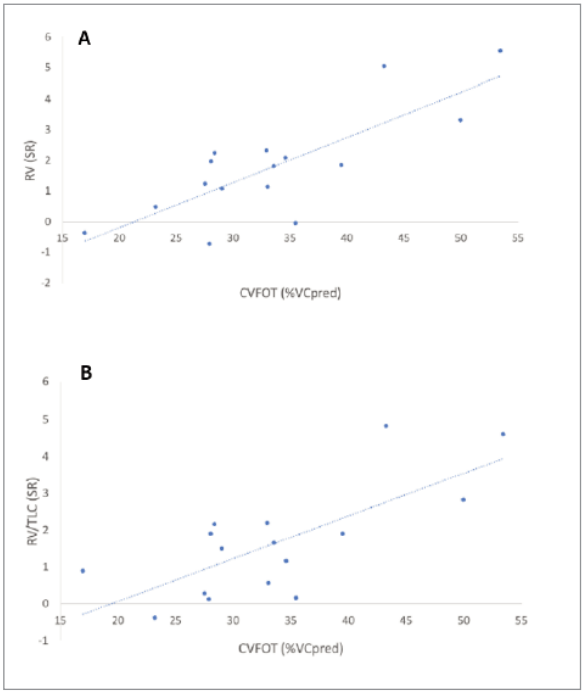


Figure 1. Comparison of RV performed as part of body plethysomography and $CV_{FOT}$ from 15 patients with confirmed diagnosis of COPD. (A) shows the relationship between RV (Standard Residual) and $CV_{FOT}$ (%VCpred). (B) shows this relationship when normalised to the patients total lung capacity using RV/TLC (Standard Residual).

**Methods**: Ethical approval was obtained from the Health Research Authority. Participants included 15 patients (5 female, 10 male; age 66.7 ± 9.5 years, height 170.7 ± 11.3cm and weight 76.8 ± 14.5kg) with a known diagnosis of COPD. On the day of examination, measurements of respiratory impedance and closing volume using FOT (Resmon Pro Full Restech, Milano-Italy) at 5, 11 and 19 Hz and static lung volumes by body plethysmography (Jaeger Master-screen, Vyaire Medical, Germany) were performed. Results analysed utilising Pearson's correlation (v1.2.0; R Studio, 2023) to determine the relationship between measurements.

**Results**: When examining the relationship between CVFOT [%Vital Capacity (VC) predicted] and residual volume (RV) measured by body plethysmography Standard Residual (SR), analysis identified a strong positive (R = 0.735) and significant (P-Value = 0.001) correlation.

**Conclusion**: The results of this study highlights the potential utility of CVFOT in determining the presence of gas trapping in comparison to results from body plethysmography. Additional research to better identify the specificity and sensitivity of these tests against already established markers of pathophysiology in a larger cohort is warranted including the examination of results in other pathologies which cause obstructive lung disease.

### P11

### How much does gas transfer add to diagnostic yield when spirometry is "normal" using Bayesian and non-Bayesian approaches?

**Mr. Oliver Stackhouse, Dr Gareth Walters, Dr Christopher Huntley, Prof. Sherwood Burge, Mr. Samuel Wallbanks**

*Birmingham Heartlands Hospital, Birmingham, United Kingdom*

**Rationale**: Previous evidence shows a 37.8% increase in diagnostic yield when gas transfer is used supplementary to a "normal" spirometry based on conventional spirometry interpretation criteria (1). However, in individuals with a higher pre-test probability of lung restriction, smaller deviations from the predicted forced vital capacity (FVC) may be considered pathological.

**Research question**: How much value does gas transfer add, in addition to spirometry, when a Z score of -1.645 (ARTP) and -1 (Bayesian) are applied to classify the FVC?

**Methods**: Retrospective analysis of 560 patients confirmed to have ILD in the Birmingham Regional ILD

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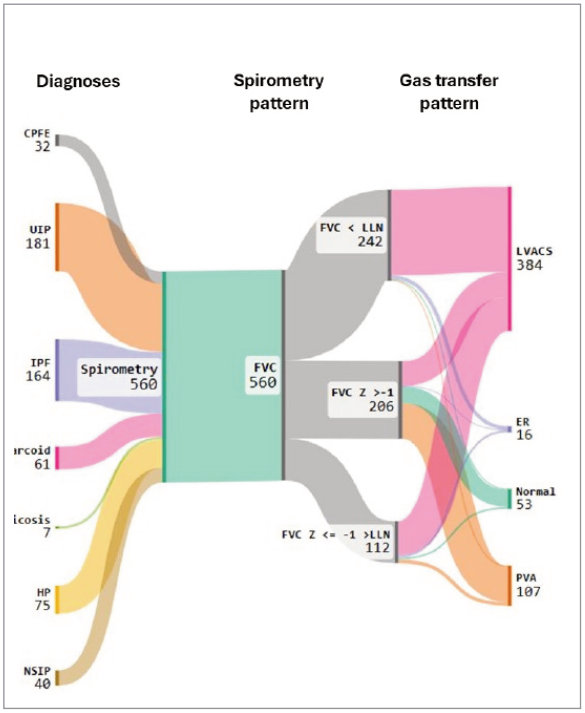
multidisciplinary team (MDT) meeting was performed between 2015 and 2025. Evaluation of the frequencies and proportions of patients considered to have "normal" lung function was performed using different cut-off thresholds. Lung function patters were split into normal, loss of volume and capillary structure (LVACS), extrapulmonary restriction (ER), and pulmonary vascular abnormality (PVA), based on ERS interpretive guidelines(2).

**Results**: Spirometry was diagnostic in itself in 242 (43.2%) and 354 (63.2%) cases when Z scores of -1.645 and -1 were applied, respectively. The addition of gas transfer identified 268 (47%) and 161 (28.7%) additional abnormalities, supplementary to spirometry, when Z scores of -1.645 and -1 were applied. The sensitivity of FVC to predict a low VA increased from 61.2% to 85.9% when a FVC Z score of -1 is used instead of -1.645. See figure for Sanke diagram of breathing test outcomes.

**Conclusion**: Use of a Bayesian approach to classifying FVC increases the diagnostic yield in patients with a high pre-test probability of ILD. LVACS (VA reduced, KCO normal or reduced) was the most common lung function pattern seen in the local ILD population. An FVC Z score of -1 is highly sensitive to a reduced VA in these individuals with high pre-test probability for ILD.

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### P12

## A comparison of lung volumes measured with the MiniBox+ versus conventional plethysmography: a case for thinking outside the box?

**Mr. Oliver Stackhouse[1], Mr. Samuel Wallbanks[1], Mr. Maximilian Thomas[2]**

*[1]University Hospitals Birmingham, Birmingham, United Kingdom, [2]University Hospitals Sussex NHS Foundation Trust, Brighton, United Kingdom*

**Introduction**: Body plethysmography is the gold standard assessment for lung volumes. However, numerous barriers exist to making a reliable measurement and implementing practically in clinical settings. Alternative approaches to measuring total lung capacity (TLC), thoracic gas volume (TGV) and residual volume (RV) are therefore needed.

Research question: Do the MiniBox+-derived lung volume measurements agree with conventional body plethysmography results?

**Methods**: Between dates May 2024 and January 2025, 33 consecutive patients and 16 healthy controls had lung volumes assessed using the Platinum Elite™ body plethysmograph (MedGraphics) and Minibox+ (PulmOne) as part of a local service improvement project. Lung volumes measurements were made with both pieces of equipment, in accordance with ARTP standards for acceptability and reproducibility (1). The order of lung volumes measures with each method was alternated to reduced bias related to training effect. Agreement in TLC, TGV, RV and vital capacity (VC) between the two methods was assessed using Bland-Altman plots. After testing for normality, tests of difference were performed, with statistical significance accepted at a level of $p<0.05$.

**Results**: In MiniBox+ versus Platinum Elite™ body plethysmography, volumes were measured significantly higher for MiniBox+ for TGV [3.3 L (2.57-3.84) vs 2.77 L (2.33-3.21), $p<0.0001$)], TLC [5.57 L (4.74-6.11) vs 5.26 L (4.5-5.81), $p<0.0001$] and VC [3.49 L (2.79-3.98) vs 3.29 L (2.6-3.8), $p<0.0001$). RV was not significantly different between MiniBox+ and Platinum Elite™ body plethysmograph groups [2.04 L (1.59-2.4) vs 1.93 L (1.47-2.16), $p=0.106$). There were no significant differences in attempts to achieve reproducibility in MiniBox+ versus Platinum Elite™ groups [4 (3-5) vs 5 (4-5), $p = 0.176$)]. Bland-Altman analysis showed the highest bias for TGV (-0.5251) when compared to TLC (-0.316), RV (-0.109) and VC (-0.1066). See Figure for Bland-Altman analysis graphs.

**Conclusion**: MiniBox offers an alternative to conventional plethysmography that can be performed with acceptable and reproducible standards. There is a bias in favour of

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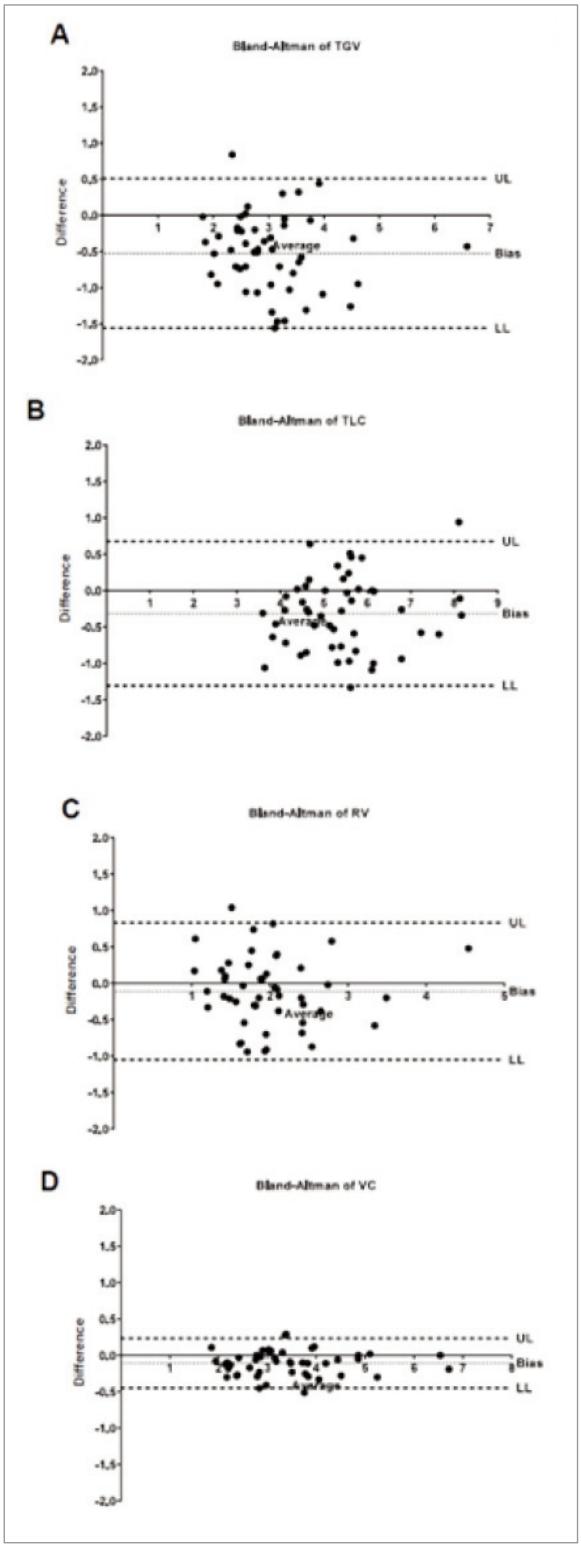


larger TLC and TGV values with the MiniBox versus conventional plethysmography.

### Reference

1. Sylvester et al, 2020. ARTP statement on pulmonary function testing, BMJ Open Respiratory Research.

### P13

## Comparison of Thoracic Gas Volume Using ARTP Guidelines For Thermal Equilibrium Versus Manufacturer Recommendations

**Miss Sara McNamara, Dr James Stockley, Prof Brendan Cooper**

*University Hospitals Birmingham, Birmingham, United Kingdom*

**Introduction**: The ARTP had previously recommended 2 – 4 minutes for plethysmographic thermal equilibrium before measuring thoracic gas volume (TGV), although their most recent guidelines simply recommend allowing for "sufficient time" for thermal equilibration (Sylvester et al. BMJORR 2020:5;7(1): e000575). Our current equipment provider recommends an equilibration period of 45 seconds – 1 minute. We sought to determine if these conflicting recommendations yielded different results.

**Methods**: This is a prospective pilot study of TGV measurement (MedGraphics Platinum Elite, Tewksbury, UK) in 7 staff members at the time of submission (with more due to be recruited). The ability of participants to perform technically acceptable and reproducible TGV manoeuvres was predetermined via biological quality control. Once the plethysmograph was sealed, participants performed TGV measurements at 45 seconds, 2 minutes, 3 minutes, and 4 minutes. A thermometer was placed inside the plethysmograph and temperature was recorded at each time point. Serial measurements of both TGV and temperature were compared using a repeated measures ANOVA test.

**Results**: Participants were 5 males and 2 females of mean age 32 (range 23 – 66), mean BMI 25.1kg/m$^2$ (SEM 1.24) with no history of respiratory disease and previous plethysmographic lung volumes within normal limits. Temperature increased significantly over the 4-minute testing period ($p < 0.0001$) but there was no significant difference in TGV (Table 1).

| | 45 secs | 2 min | 3 mins | 4 mins | p = |
|---|---|---|---|---|---|
| **TGV (L)** | 3.03 (0.28) | 3.07 (0.24) | 3.06 (0.29) | 3.12 (0.29) | ns |
| **Temperature (°C)** | 24.7 (0.57) | 25.9 (0.55) | 27.0 (0.44) | 27.6 (0.53) | < 0.0001 |

Table 1: A summary of TGV measurements and plethysmograph temperature across the 4 time points of the testing protocol (n=7). Data are presented as mean and standard error (SEM). VTG did not differ signficiantly (p=ns) despite a significant increase in plethysmograph temperature (p<0.0001)

**Conclusions**: Our pilot data suggest that the discordance in guidelines of thermal equilibrium time does not influence TGV measurement, at least in healthy individuals. However, our current data set is limited and would need to be extended to include patients with respiratory disease before definitive conclusions can be made.

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## 1st–2nd May, Scottish Exhibition Centre, Glasgow

### P14

### Can alveolar volume (VA) be used as a surrogate for total lung capacity in patients with interstitial lung disease(s)?

**Miss Robyn Gregory, Dr Christopher Huntley, Dr Gareth Walters, Mr. Samuel Wallbanks**

*Birmingham Heartlands Hospital, University Hospitals Birmingham NHS Foundation Trust, Birmingham, United Kingdom*

**Introduction**: Recent analyses have shown high concordance between alveolar volume (VA) and total lung capacity (TLC) in patients with restrictive lung conditions (Alexiou et al, 2024). Given the high burden of care for people with interstitial lung disease (ILD), we aimed to validate these findings in a cohort of patients with confirmed ILD.

**Research question**: Can VA be used as a surrogate for TLC in patients with known ILD?

**Methods**: Retrospective analysis of 560 patients diagnosed with ILD between 2015 and 2025 at the Regional Birmingham Multidisciplinary Team (MDT) meeting was performed. Patients with both gas transfer and lung volume (helium dilution & nitrogen washout) measures were included. Sensitivity, specificity, positive and negative predictive value (PPV & NPV, respectively) of VA to predict TLC were calculated, based on a Z score cut-off threshold of above or below -1.645. Sub-analysis was performed for patients with ILD with co-existing obstruction on baseline spirometry. Tests of difference were performed between obstructive and non-obstructive groups, with statistical significance accepted when $p < 0.05$.

**Results**: Of 560 patients, 435 had both gas transfer and lung volume measures (77.6%). The median difference between VA and TLC was 212 mL (156 – 496 mL). VA was highly predictive of TLC in patients with confirmed ILD, with a sensitivity of 95.3%, specificity of 78.4%, PPV of 90.8% and NPV of 88.2%. In the 38 patients with ILD with co-existing airflow obstruction on spirometry, larger differences between VA and TLC were present (427 mL (185 – 862 mL), p= 0.025). Despite this, VA to predict TLC still had a sensitivity of 100%, specificity of 75.9%, PPV of 56.3% and NPV of 100% in this group.

**Conclusion**: Measurements of VA are highly concordant with measurements of TLC (using dilution methodologies) in patients with ILD, including those with co-existing airflow obstruction.

**Reference**

Alexiou et al (2024), ERJ. The utility of gas transfer measurement to identify low total lung capacity.

### P15

### Reinterpreting Pulmonary Function Tests: Clinical Impacts of Shifting from Race-Specific to Race-Neutral Equations

**Mr. Rhys Tudge**

*Manchester University NHS Foundation Trust, MANCHESTER, United Kingdom; Manchester Metropolitan University, Manchester, United Kingdom*

**Introduction**: Pulmonary Function Testing (PFT) interpretation compares actual measurements with predicted values derived from a global dataset of healthy non-smokers. While race and ethnicity have historically informed these interpretations, their use is increasingly questioned due to their potential to perpetuate health disparities. To standardise PFT interpretation, the Global Lung Function Initiative (GLI) developed race-specific reference equations (2012), but limitations were recognised. In 2022, GLI introduced race-neutral equations. This study evaluates the impact of transitioning from race-specific to race-neutral equations on PFT interpretations in a local patient sample.

**Methods**: A retrospective service evaluation using PFT data from 5716 patients aged 18-95. Datasets were reanalysed using GLI global 2022 race-neutral and compared to the existing GLI 2012 race-specific reference equations. Results were stratified by self-reported ethnicity (White, Black, and Other/Mixed) to assess clinical implications.

**Results**: The mean difference in FEV1 Z-scores between race-specific and race-neutral reference equations was -0.31 [LOA: 0.08; -0.71] in the white cohort, 0.53 (LOA: 0.93; 0.13) in the black cohort, and -0.06 (LOA: 0.36; -0.49) in the Other/Mixed cohort. Race-neutral equations predicted lower FEV1 Z-scores in Black individuals than race-specific equations, whereas in White individuals, they predicted slightly higher FEV1 Z-scores. Minimal differences were observed in the Other/Mixed cohort.

Race-neutral equations increased the prevalence of lung function impairment by 1.9% in the White cohort, 11% in the Black cohort, and 0.65% in the Other/Mixed cohort. Applying race-neutral equations increased obstruction prevalence by 3.5% in the White cohort, with minimal changes in the Black and Other/Mixed cohorts. Restriction prevalence increased by 10.9% in the Black cohort but decreased by 4.6% and 3.2% in the White and Other/Mixed cohorts, respectively. Obstruction severity changed in 9.2% of White, 8% of Black, and 7.8% of Other/Mixed individuals. Overall, 8.1% of patients had interpretation changes from race-specific to race-neutral equations.

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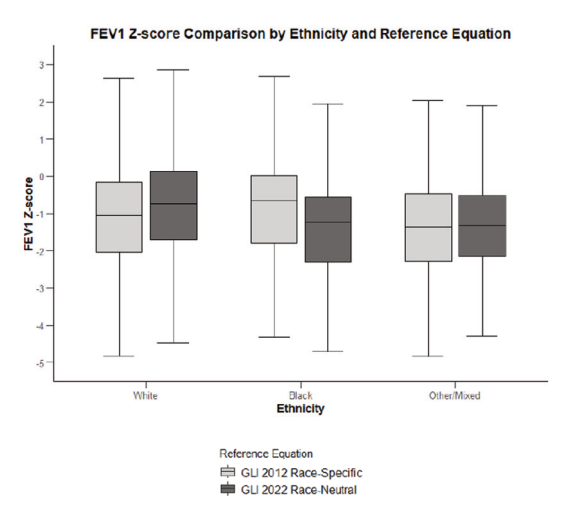


**Conclusion**: The adoption of GLI Global 2022 race-neutral reference equations will significantly impact spirometry interpretation, particularly in Black individuals. Clear communication with clinical teams is essential to ensure awareness of these changes and their implications. While the shift to race-neutral equations represents progress, further research, especially in non-white cohorts, is needed to fully evaluate its clinical impact.

### P16

### Comparing the impact of Global Lung Initiative 2012 and 2021 Predictive Values for Interstitial Lung Disease Severity Classification and Monitoring.

**Mr. George Bingham, Mr. Dom Evans, Ms. Elizabeth Lancaster, Mr. Calvin Apen, Mr. Muhammad Khan**

*York And Scarborough Teaching Hospitals, York, United Kingdom*

**Introduction**: A decline in forced vital capacity (FVC) exceeding 10% is a well-established prognostic marker in interstitial lung disease (ILD) [1]. The 2021 Global Lung Initiative (GLI) reference values for relaxed vital capacity (RVC) yield a more severe disease classification than the 2012 GLI FVC values in idiopathic pulmonary fibrosis [2]. This study examines how these differing reference equations influence ILD severity classification and progression monitoring.

**Methods**: Retrospective spirometry analysis in ILD patients (August 2022–2023, n=169). For each patient, we recorded %predicted values and z-scores, and disease severity was graded using the American Thoracic Society/European Respiratory Society and the Association for Respiratory Technology & Physiology criteria. Paired t-tests were used to analyse differences. We compared baseline classifications and lung function changes between patients evaluated with a consistent predictive model and those with alternating models between visits. Differences in %predicted values and z-scores were then examined to assess the impact of switching models. Clinical Governance Approval was obtained.

**Results**: GLI 2012 produced a mean FVC %predicted of 88.1% (z-score –0.79), significantly higher than the 82.6% (z-score –1.31) from GLI 2021. Consequently, more patients were classified as moderately to severely impaired. Consistent model use led to minor %predicted reductions (2.4% and 2.0% for GLI 2012 and GLI 2021, respectively). Longitudinal analysis revealed larger shifts when switching from GLI 2012 to GLI 2021; FVC %predicted decreased by 6.59% with this switch, compared to a 2.19% reduction with the alternative order. Similar trends were observed in z-score differences. Baseline differences and changes observed with model switching were approximately twofold greater in non-Caucasian patients.

**Conclusions**: The choice of GLI reference model significantly affects ILD severity classification and progression monitoring. Our findings indicate that the 2021 GLI values may be more sensitive in detecting both early and advanced impairment, highlighting the benefit of considering both RVC and FVC in longitudinal monitoring. To avoid systematic bias and misinterpretation, clinicians should consistently use the same predictive model when tracking ILD patients.

**References**

1. Eisa et al. Rheumatology 2024; 63
2. Donovan et al. ERJ 2023; 62

### P17

### Validating a pre-flight algorithm for predicting in-flight oxygen in patients with Interstitial Lung Disease.

**Miss Lucy Robertson, Dr Karl Sylvester, Dr Helen Parfrey, Dr Muhunthan Thillai, Dr Nicola Simler, Dr Benjamin Knox-Brown**

*Royal Papworth Hospital, Cambridge, United Kingdom*

**Introduction**: A pre-flight algorithm developed by Barrett et al. (Respi Med. 2018 135:51-56) advises which interstitial lung disease (ILD) patients may require inflight oxygen. The algorithm recommends that inflight oxygen is not required when the partial pressure of oxygen (PaO2) > 9.42 kPa and transfer factor for carbon monoxide (TLCO) > 50% predicted. It is recommended when both PaO2 and TLCO are below these values. The British Thoracic Society Clinical Statement on Air Travel (2022) adopted these recommendations for hypoxic challenge test (HCT)

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in ILD but emphasised that validation is needed in ILD cohorts.

**Objectives**: Determine the algorithm accuracy (Barrett et al. 2018) to predict HCT outcomes in our ILD cohort. Determine which physiological parameters can be used to best predict HCT outcomes in our ILD cohort.

**Method**: Retrospective data were collected from 130 ILD patients from Royal Papworth Hospital NHSFT. Sensitivity and specificity values were calculated. The predictive power of physiological factors for a pass HCT outcome, and optimal cut-off thresholds were determined using receiver operating characteristics (ROC) curve analysis. Binomial logistic regression identified independent predictors for passing a HCT. Optimal thresholds were statistically compared using ROC analysis.

**Results**: The algorithm's validation suggested that the combined cut off (PaO2> 9.42 kPa and TLCO > 50%) had low sensitivity (30.1) but high specificity (96.7%) for predicting a pass HCT outcome. Multivariate regression analyses demonstrated that the following factors were independent predictors of a successful HCT outcome: resting PaO2 > 9.30 kPa, TLCO > 43% predicted, FVC > 60% predicted and BMI. Table 1 presents the comparison of the sensitivity and specificity values and AUC between the different thresholds. PaO2 alone had the highest sensitivity for predicting a pass on HCT.

| Criteria | AUC (95%CI) | Sensitivity | Specificity |
|---|---|---|---|
| Barrett et al. (2018) | | | |
| $PaO_2$ >9.42 kPa | 0.78 (0.70-0.85) | 77.8 | 77.5 |
| TLCO>50% | 0.66 (0.59-0.73) | 38.4 | 94.6 |
| Combined ($PaO_2$ >9.42 kPa and TLCO > 50%) | 0.64 (0.58-0.70) | 31.5 | 96.8 |
| Robertson et al. (2025) | | | |
| $PaO_2$ >9.30 kPa | 0.76 (0.69-0.85) | 81.1 | 72.5 |
| TLCO>43% | 0.76 (0.68-0.84)* | 64.4 | 87.1 |
| Combined ($PaO_2$ >9.30 kPa and TLCO > 43%) | 0.74 (0.67-0.80)* | 50.7 | 96.8 |

*Significantly different from AUC of Barrett et al. (2018) cut-offs

Table 1: Comparison of sensitivity and specificity between different thresholds

**Conclusion**: The developed algorithm indicated poor sensitivity but good specificity in predicting a pass HCT outcome. We similarly identified that PaO2 and TLCO % predicted are independent predictors for a successful HCT outcome. Our findings suggest PaO2 >9.30 kPa alone had the best sensitivity and ability to predict a HCT pass.

### P18

### Can an established voluntary hyperventilation provocation test (HVPT) protocol be reduced from 3 minutes to 1 minute?

**Mrs Sara Mcarthur, Mr. Shaun Baxter, Mr. Kristofor Cuthbert**

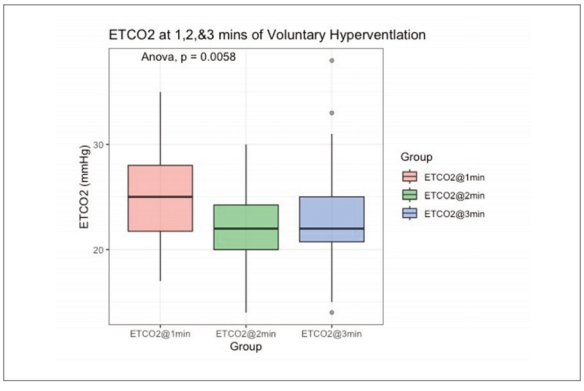
*Nhs Lothian, Edinburgh, United Kingdom*

**Background**: HVP testing has been used for > 25 years within a service to investigate a patients breathing pattern. The protocol utilises a 3-minute resting phase, then if resting values are within the normal range voluntary hyperventilation (VH) is commenced for 3 minutes followed by recovery monitoring for 3 minutes. Low PETCO2 may cause cardiac arrhythmias, coronary artery spasm and seizures (Kane et al, Seizure.2014) in susceptible patients and therefore if a shorter period of VH could be utilised within the test then this may be safer for patients. Other Services have used a 1 min VH within their protocol.

**Aim**: Can the VH stage of the HVPT be reduced from 3 minutes to 1 minute (in keeping with other Services protocol) and still elicit the required reduction in PETCO2?

**Method**: Patients that attended for HVPT over 3 months were identified, demographics and clinical details recorded. PETCO2 at 1, 2 and 3 minutes were noted in those patients who progressed to the VH stage and compared using a one-way Anova and post Hoc Tukey analysis.

**Results**: 73 patients were identified, 3 were excluded. 70 patients were included: 22 being classified as experiencing chronic hyperventilation, 22 acute and 26 showing normal PETCO2 responses. 4 patients with normal PETCO2 had evidence of a breathing pattern disorder (BPD). 48 patients went on to perform VH.
A one-way Anova was used to assess whether there was a statistical difference between PETCO2 at 1 minute, 2 minutes, 3 minutes and combinations of all 3.
P between all 3= 0.006
P between 1 and 2 minutes= 0.002
P between 2 and 3 minutes= 0.285
P between 1 and 3 minutes= 0.016




**Conclusion**: Data suggests that VH could be reduced from 3 minutes to 2 minutes. ETCO2 at 1 minute is significantly higher than at 2 minutes suggesting that either a change in protocol may be required to reduce ETCO2 to desired level or that 2 minutes of VH is required to reach "target" ETCO2. A standardised protocol for HVPT by the ARTP that offers guidance on protocol and target ETCO2 range would be desirable.

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### P19

### Investigating Hypoxic Challenge Testing Methods: Patient Preference and Physiological Insights from Venturi Mask and Mouthpiece Techniques

**Mrs Zoe Ford[1], Prof James Faulkner[1], Dr Michael Hughes[2], Dr Harry Griffin[2]**

*[1]School of Sport, Exercise and Health, University of Winchester, Winchester, United Kingdom, [2]Respiratory and Sleep Physiology Department, Hampshire Hospitals NHS Foundation Trust, Basingstoke, United Kingdom*

**Introduction**: Hypoxic challenge tests (HCT) are recommended by the British Thoracic Society to assess the requirement for in flight supplemental $O_2$. During an HCT, the $FiO_2$ is reduced to 15% replicating the $PiO_2$ experienced during air travel. Various HCT methods exist, potentially affecting clinical outcomes. In the UK, two main techniques are used, the "Venturi mask method" (V-HCT), which employs 100% $N_2$ via a 40% $O_2$ venturi barrel, and the "Mouthpiece method" (M-HCT), which uses pre-mixed 15% $O_2$ via a mouthpiece. We compared these methods in elderly individuals with airflow obstruction, hypothesising that the M-HCT would induce hyperventilation (assessed via transcutaneous $CO_2$ - $tCO_2$) and potentially yield false-negative results.

**Methods**: Participants with self-reported COPD or asthma, aged over 60 and naïve to HCT, attended the University of Winchester for a screening visit followed by two experimental visits. Spirometry during the screening visit confirmed airflow obstruction. During the experimental visits, participants completed both V-HCT and M-HCT in a random order, with continuous measurements of $tCO_2$, $SpO_2$, and HR. They also reported any claustrophobia and answered, "If asked to perform a HCT by your clinician, what test would you rather perform?"

**Results**: Twelve participants completed both HCT methods (see Table 1 for demographics). Five found the M-HCT claustrophobic, while none did for the V-HCT, and all preferred the V-HCT. In contrast to our hypothesis, $tCO_2$ levels were similar between methods, with no significant difference from baseline to the final three minutes (M-HCT: 5.1 to 5.0 kPa; V-HCT: 5.1 to 5.1 kPa). Furthermore, ten participants had lower $SpO_2$ nadirs during the M-HCT. Statistical analysis on the grouped data was not feasible as two participants' $SpO_2$ dropped <83% during the M-HCT, necessitating an $FiO_2$ increase as per ethical guidelines.

| Baseline characteristics (n = 12) | (Number of participants), [SD] |
|---|---|
| Sex, % female | 50% (6) |
| Age (years) | 70.8 [9.4] |
| Self-reported diagnosis: | |
| Asthma | 16.667% (2) |
| COPD | 83.333% (10) |
| Smoking history: | |
| Former - smoker | 91.66% (11) |
| Current - smoker | 0% (0) |
| Severity of Airflow Obstruction (using SR): | |
| Mild | 6 |
| Moderate | 1 |
| Moderately Severe | 1 |
| Severe | 4 |

Table 1: Participant demographics

**Conclusion**: Patients preferred the V-HCT, reporting less claustrophobia than the M-HCT, but no evidence of hyperventilation during either method was shown. The reason for lower $SpO_2$ with the V-HCT in ten participants remains unclear, although room air entrainment through the mask's expiratory ports, raising the $FiO_2$ is a possible explanation. Future studies are required to accurately measure the true $FiO_2$ inhaled during the Venturi technique.

### P38

### The Diagnostic Utilisation of Cardiopulmonary Exercise Testing (CPET) in Unexplained Breathlessness (UB)

**Dr Claire Griffith-McGeever**

*Betsi Cadwaladr University Health Board (BCUHB) NHS, Wrexham, Wales, United Kingdom*

**Introduction**: Patients with the persistent physical symptom of breathlessness often undergo numerous investigations over a prolonged period of time to help determine the underlying cause without achieving a clear diagnosis or management plan. Cardio-Pulmonary Exercise Testing (CPET) is increasingly becoming the "go to" investigation in this population. This study is a retrospectively review of the outcomes for patients referred for investigation of unexplained breathlessness (UB) following a joint physiologist and consultant review.

**Methods**: All patients with UB referred for CPET who were reviewed in a multidisciplinary discussion with respiratory physiologists and consultants between September 2023 and November 2024 (Table 1) were included in this retrospective review

**Results**: Eighty-five patients were referred for UB (42 males; 43 females = age 56.8 years [16.0-86.0], BMI 30.8 kg.m2 [18.8-50]. Thirty-four percent (n = 29) of patients demonstrated a normal response to exercise (i.e., no cardiac/respiratory limitations to exercise), the most common outcome, and were consequently discharged from the service with no further recommendation for investigation. Twenty-two percent of patients (n = 19) were found to have evidence suggestive of cardiac limitation to exercise (e.g., chronotropic incompetence. Additionally, fifteen percent of patients (n = 13) were found to be generally deconditioned and given lifestyle advice. A further eighteen referrals were made to other services

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based upon the discussion of the CPET (e.g., dietetics/weight loss advice, chronic complex conditions (CCC) service, physiotherapy/breathing pattern disorder (BPD) +/- speech and language therapy).

| Demographics | Mean (IQR) | CPET Outcomes | Total *n* = 85 (%) |
|---|---|---|---|
| Sex (male/female *n*) | 42/43 | Cardiology | 19 (22) |
| Age (years) | 56.8 (16.0-86.0) | Respiratory | 9 (11) |
| BMI (kg · m²) | 30.8 (18.8-50.0) | BPD | 9 (11) |
| **Indications for testing** | **Total *n* = 85 (%)** | ENT | 2 (2) |
| Breathlessness? Cause | 61 (72) | Deconditioning | 13 (15) |
| Post Covid SOB | 5 (6) | Mobility | 1 (1) |
| Exercise-induced Asthma? | 5 (6) | Normal | 29 (34) |
| ACHD | 7 (8) | Pain | 3 (4) |
| BPD? | 7 (8) | **Onward Referrals** | **Total *n* = 18 (%)** |
| **Previous Investigations** | **Total *n* = 204 (%)** | Pulmonary rehab | 2 (11) |
| Cardiology | 43 (21) | Physiotherapy | 2 (11) |
| Respiratory | 47 (23) | Smoking cessation | 1 (6) |
| Radiography | 81 (40) | Cardiology | 2 (11) |
| Microbiology | 26 (13) | Rheumatology | 1 (6) |
| Pathology | 2 (1) | CCC | 4 (22) |
| Ultrasound | 2 (1) | Sleep | 1 (6) |
| Endoscopy | 3 (1) | Dietetics | 1 (6) |
| | | Tertiary service | 4 (22) |

Table 1: Unexplained breathlessness (UB) pathway outcomes

**Conclusion**: The review has provided us with clearer outcomes/diagnosis for patients referred for the investigation of UB. It has also raised a number of questions, could and should CPET be used earlier in the investigation of patients' presenting with persistent unexplained breathlessness to make better use of finite hospital resources. How does this kind of service improve patient outcomes, what should those outcomes be, and does it reduce the subsequent presentation of patients with persistent physical symptoms of breathlessness? The increase in referrals for CPET for this this reason has increased suggesting that clinicians find it a useful investigation for the management of their patients.

### P39

## Comparison of the standard 6-minute walk test with a normal-speed 6-minute walk test to assess ambulatory oxygen requirement.

**Dr Michael Hughes[1], Miss Madison Geeves[1], Miss Megan Leonard[1], Mr. Harry Kirby[1], Mrs Zoe Ford[1], Prof James Faulkner[2], Prof Dilwyn Marple-Horvat[3], Dr Harry Griffin[1]**

*[1]Respiratory and Sleep Physiology, Hampshire Hospitals NHS FT, Basingstoke, United Kingdom, [2]School of Primary Care, Population Sciences and Medical Education, Primary Care Research Centre, University of Southampton, Southampton, United Kingdom, [3]Research Centre for Musculoskeletal Science & Sports Medicine, Manchester Metropolitan University, Manchester, United Kingdom*

**Introduction**: The standard 6-minute walk test (6MWT) involves asking the participant to walk as far as they can around a straight flat course (usually a corridor) for 6 minutes whilst their oxygen saturation (SpO2), heart rate (HR) and total distance walked (6MWD) are recorded. Many patients will walk slower during their normal daily activity, and therefore may not be an accurate assessment for their requirement for ambulatory oxygen therapy (AOT). We aimed to identify any clinical differences between the standardised 6-minute walk test and a proposed normal-speed 6-minute walk test.

**Methods**: Two 6MWT were performed under the same conditions with instructions to either walk either as far as they can (M-6MWT, following international guidelines), or at their normal walking pace (N-6MWT) for 6 minutes. A wireless SpO2 probe and tablet were used to continuously measure SpO2, HR and a lap counter to record total distance. A modified BORG scale was used to assess perceived breathlessness and fatigue, as well as a standard activity questionnaire to assess normal daily activities. A minimum 10-minute rest period was provided between tests.

**Results**: There was a statistically significant increase in the 6MWD with the M-6MWT compared with the N-6MWT (Figure 1A: mean 6MWD 420m vs. 352m) with a corresponding small, yet statistically significant, decrease in the SpO2 nadir (Figure 1B; mean SpO2 nadir 89.0% vs. 88.4%). The change in SpO2 nadir was more marked when only participants that met eligibility criteria for AOT (SpO2 nadir <90% and ≥4% decline from baseline) in the M-6MWT (n=41) were included in the analysis. Furthermore, within this group, 7 participants (17%) would not have met eligibility criteria for AOT on the N-6MWT.

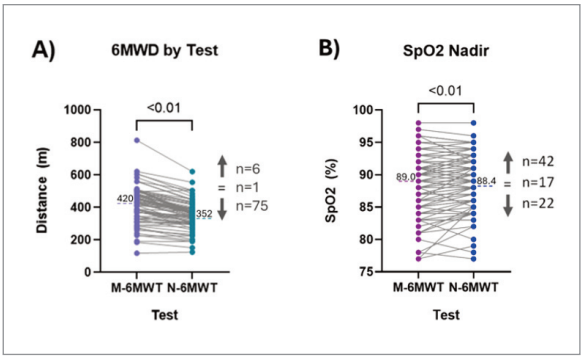


Figure 1. Differences in 6MWD and SpO2 nadir between the M-6MWT and N-6MWT. (A) paired data showing the 6MWD in meters (m) achieved for each participant in the M-6MWT (purple) and N-6MWT (teal) with the mean value indicated by the horizontal dashed line. The total number of participants that demonstrated an increase, decrease or identical 6MWD between the two tests are shown to the right (n=82). (B) SpO2 nadir between the M-6MWT (purple) and N-6MWT (blue) for each participant. The total number of participants that demonstrated an increase, decrease or identical SpO2 between the two tests are shown to the right (n=81).

Statistical analysis was performed using a paired t-test. In all cases, $p<0.05$ was considered statistically significant.

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**Conclusion**: These results suggest that the instructions given for the 6MWT may have clinical impact for the assessment of both functional capacity (6MWD) and for ambulatory oxygen requirements. These data highlight the importance of standardisation of testing to support robust clinical decision making. Further work is required to assess if the modified test provides a better indication for ambulatory oxygen, but the M-6MWT will show a better indication of true functional capacity from the 6MWD.

### P40

### Cardiopulmonary Exercise Testing in Heart Failure with Preserved Ejection Fraction: A Game-Changer for Patients

**Dr Saqib Javaid[1], Prof. Chris Bleakley[2], Prof. George Kernohan[2], Dr Rachel Savage[2], Dr Peter McKavanagh[3], Dr Elena Connell[3]**

*[1]Ulster University and Ulster Hospital, Belfast, United Kingdom, [2]Ulster University, Belfast, United Kingdom, [3]Ulster Hospital, Belfast, United Kingdom*

**Background**: Identifying heart failure with preserved ejection fraction (HFpEF) remains challenging. Scoring systems suggested by European Heart Failure Association (HFA-PEFF score) and Reddy et al. 2018 (H2FPEF score), are commonly used in clinical practice. Practically speaking, the majority of the patients remain unidentified as they fall into an intermediate/require further evaluation scoring category, creating a diagnostic "gray zone." As a non-invasive and potentially more cost-effective investigation, cardiopulmonary exercise testing (CPET) could help solve this problem. The study aimed at understanding the role of CPET in the identification of patients with HFpEF.

**Methods**: As a part of a bigger project, a pilot study cross-sectional study was conducted at the Cardiac Investigative Unit, Ulster Hospital, Belfast. The study involved 13 patients recruited via the hospital system with clinical suspicion of HFpEF based on symptoms and echocardiographic findings (LVEF>50%). We assessed the HFpEF probability using the HFA-PEFF and the H2FPEF score. All patients went through cardiopulmonary exercise testing till exhaustion yielding a valid test. We hypothesized that CPET parameters (VO2peak, VE/VCO2 slope, and OUES) might provide complementary information to aid the identification of HFpEF on top of probability HFA-PEFF and H2PEFF scores.

**Results**: A total of 13 HFpEF patients with age 61.7 ± 5.6 years were included. Based on the HFA-PEFF and H2PEFF scoring system, out of the 13 patients, 8 (61.5%) were found to be in the “needs further evaluation” category, while 3 (23.1%) were based highly unlikely HFpEF and 2 (15.4%) highly likely HFpEF categories. CPET results of 8 unidentified patients showed, VO2peak, VE/VCO2, and OUES to be VO2peak and VE/CO2 and OUES were recorded to be 13.8 ± 1.4 and 39.4 ± 9.8 and 1503 ± 1235 respectively. These patients fell into the categories of Webers Class III and Ventilatory Class III showing low cardiorespiratory and ventilatory efficiency corresponding highly with HFpEF.

**Conclusion**: CPET can be a vital investigatory tool that would augment the current scoring system and help in identifying HFpEF patients early in their disease timeline and may be used to initiate appropriate early targeted management.

### P41

### CPET Panel 8: RER vs Time – What MORE can it tell us than just Test Validation in Heart Failure?

**Dr Saqib Javaid[1], Prof George Kernohan[2], Prof Chris Bleakley[2], Dr Rachel Savage[2], Dr Peter Mckavanagh[3], Dr Elena Connell[3]**

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**Background**: Panel 8: Respiratory Exchange Ratio (RER) vs Time, of CPET output has been predominantly used as an objective index to evaluate exercise effort and validate a maximal test (RER ≥1.1). However, a transient increase (overshoot) in respiratory gas analyses, depicted as a rise in RER, has been observed during exercise recovery and may prove to have clinical significance in patients not clearly understood. The study aimed to analyse the clinical relevance of RER behaviour after a maximal effort and to understand if this could correlate with other CPET parameters in patients with Heart Failure with preserved ejection fraction (HFpEF).

**Methods**: This cross-sectional study included 13 patients of HFpEF identified via the European Society of Cardiology guidelines who underwent a maximal CPET with over 2 minutes of recovery phase at the Cardiac Investigative Unit, Ulster Hospital, Belfast. VO2peak and VE/VCO2 slope were recorded. RER behaviour (Panel 8) during recovery was evaluated by assessing maximal value (RER max), the magnitude of RER overshoot (RER mag) which is the percentual value of the difference between RER max and RER peak. Data represented a mean ± S.D with correlation and regression applied. P value <0.05 was considered significant.

**Results**: Thirteen (13) patients with HFpEF were included (61.7 ± 5.6 years; 84% male). VO2peak and VE/CO2 were recorded to be 16.3 ± 4.6 and 35.8 ± 10.9, respectively. The mean RER recovery overshoot was recorded at

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15.8 ± 7.0% which is even lower than results in heart failure with reduced ejection fraction (Vecchiato et al, 2024). RER overshoot magnitude showed a significant positive correlation with VO2peak (r = 0.648, p =0.017). Correlation between RER magnitude and VE/VCO2 was found to have a negative weak/non-significant (r = -0.167, p=0.631). One patient showed negligible RER overshoot, showing worse metabolic (VO2peak: 14.9 ml/kg/min) and ventilatory efficiency (VE/VCO2: 39.43) when compared to others.

**Conclusion**: RER overshoot may prove to be a meaningful cardiorespiratory index to monitor using CPET testing in HF patients having the potential to support clinicians in interpreting patients' functional impairment and prognosis comprehensively. Thus, analysis of CPET recovery parameters is recommended in clinical decision-making.

### P42

### Using respiratory exchange ratio as a retrospective marker of maximal exertion during cardiopulmonary exercise tests: A systematic review

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

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**Introduction**: Cardiopulmonary exercise tests are used to assess pre-operative risk, integrated cardio-respiratory responses to exercise and peak aerobic capacity, therefore achieving maximal exertion is important. Currently, there is no consensus for defining maximal effort, although an elevated respiratory exchange ratio (RER) is suggested. Recent findings illustrate an RER of ≤1.05 can underestimate some patients' true maximal exercise capacity (Thomas et al. BMJ 2021). We aim to create the first evidence-based consensus regarding the consistency of using an RER to determine a maximal CPET across age groups and exercise modalities via a systematic review (PROSPERO registration CRD42023454768).

**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*"). Studies included human participants with an exercise duration of >6minutes. Studies were excluded if they were an abstract or not written in English language. The RERs utilised were compared.

**Results**: 532 studies met the inclusion criteria. 25% and 53% of the adults and paediatrics respectively, used an RER cut-off of either <1.05 or ≥1.05. In the adult population this equates to 117,821 subjects. A Mann-Whitney U test via SPSS showed a significant difference in RER values between adults and paediatrics, U=17181.500, p<0.001 (Table 1).

| | | | Number of studies using specific RER criteria to determine maximality (n (%)) | | | | |
|---|---|---|---|---|---|---|---|
| | Studies (n (%)) | Total patients (n (%)) | RER <1.05 | RER ≥ or > 1.05 | RER ≥ or >1.10 | RER ≥ or >1.15 | RER ≥ or >1.2 | Other RER |
| **Adults (total)** | **487** | **173133** | **79 (16%)*** | **42 (9%)*** | **265 (54%)*** | **82 (17%)*** | **9 (2%)*** | **10 (2%)*** |
| Cycle Ergometry | 160 (33%) | 73188 (42%) | 31 (19%) | 20 (9%) | 111 (53%) | 37 (18%) | 4 (2%) | 7 (3%) |
| Treadmill | 229 (47%) | 92975 (54%) | 40 (17.47%) | 20 (8.7%) | 122 (53.3%) | 41 (17.9%) | 5 (2.2%) | 1 (0.4%) |
| Other | 48 (10%) | 6970 (4%) | 8 (16%) | 2 (4%) | 32 (66%) | 4 (10%) | 0 (0%) | 2 (4%) |
| **Paediatrics (total)** | **103** | **8194** | **47 (45%)** | **8 (8%)** | **36 (35%)** | **7 (7%)** | **0(0%)** | **5 (5%)** |
| Cycle Ergometry | 45 (44%) | 4661 (57%) | 19 (43%) | 1 (2%) | 16 (36%) | 4 (9%) | 0 (0%) | 5 (11%) |
| Treadmill | 50 (47%) | 3322 (40%) | 27 (54%) | 6 (12%) | 14 (28%) | 3 (6%) | 0 (0%) | 0 (0%) |
| Other | 8 (8%) | 211 (3%) | 1 (12.5%) | 1 (12.5%) | 6 (75%) | 0 (0%) | 0(0%) | 0 (0%) |

Table 1: Results of the 532 studies which met the inclusion criteria (please note of the 532 studies which met the inclusion criteria some studies have utilised both multiple age groups and exercise modalities). *p=<0.001 compared to paediatrics. Other statistical analysis revealed no significant difference in the RER values used dependent on the CPET modality

**Conclusions**: A variety of RER values have previously been utilised to determine maximal exertion, which is significantly different between adult and paediatric populations. One quarter of studies in the adult population have utilised an RER cut-off of <1.05 or ≥1.05, which could mean 117,821 subjects may have not achieved their peak aerobic capacity if the RER is the sole determinant of maximal exertion. If replicated clinically, this may influence a patient's diagnosis and assessment of surgical risk. The lack of consistency in RERs used to determine a maximal CPET undermines and complicates clinical practice. Critically, the RER should not be used as a sole determinant of maximal exertion.

### P44

### Heart rate recovery as a predictor of clinical decline in pulmonary hypertension

**Miss Lucy Robertson[1], Dr Benjamin Knox-Brown[1], Dr Joanna Pepke-Zaba, Dr Mark Toshner, Dr John Cannon, Dr Katherine Bunclark, Dr Karen Sheares, Dr Dolores Taboada Buasso, Dr Joseph Newman**

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**Background**: Heart rate recovery (HRR) can be impaired in pulmonary hypertension (PH) due to autonomic dysfunction and may confer prognostic information.

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**Aim**: To examine the association between HRR% 1 minute (HRR1%) or HRR% 30 seconds (HRR30%) post 6-Minute Walk Test (6MWT) and subsequent clinical decline in patients with PH.

**Methods**: Retrospective 6MWT data collected between July-September 2023 were paired with outcome data regarding clinical decline (mortality, transplantation, treatment escalation, admission or 15% decrease in 6MWD). Receiver operating curve analysis was used to identify optimal cut off values for 6MWD, HRR1% and HRR30%.

**Results**: Of 110 patients (predominantly WHO PH Groups 1 & 4), 19 experienced clinical decline over a median follow up time of 532 (511-550) days. 6MWD, HRR1%, and HRR30% all had significant and comparable area under the curves (AUCs) of 0.85, 0.88, and 0.88, respectively, for predicting deterioration. 6MWD had a specificity of 91% and sensitivity of 68%. HRR1% and HRR30% both had specificity of 83% and sensitivity of 79%. Optimal cut off values calculated for 6MWD, HRR1% and HRR30% were 300 meters, 12.5%, and 4.5%, respectively. The combined criteria [6MWD<300 OR HRR1%<12.5%] and [6MWD<300 or HRR30%<4.5%] had improved sensitivity of 95% with specificities of 59% and 75% respectively. Data collection is on-going for further validation.

**Conclusion**: 6MWD has high specificity for clinical decline, but relatively lower sensitivity. HRR has high sensitivity however, so prognostication in PH may be improved by incorporating measures of HRR, an easy-to-measure metric.

### P45

### Chronotropic incompetence in Idiopathic Pulmonary Fibrosis (IPF): The potential impact on exercise capacity.

**Mr. Ben Bowhay[1,2,3], Professor Craig A Williams[2,3,4], Professor Michael A Gibbons[2,3], Professor Chris J Scotton[1,2,3], Dr Owen Tomlinson[1,3]**

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**Introduction**: Chronotropic incompetence (CI) relates to the inability of the cardiac system to respond appropriately to metabolic demand, which decreases exercise capacity, including peak oxygen uptake (VO2peak). This occurs because of abnormal heart rate (HR) responses, which are delayed during submaximal exercise and slower to recover following exertion; which may impact exercise prescription methods that rely on HR. This study is the first to focus solely on CI in Idiopathic Pulmonary Fibrosis (IPF), as previous work took a broader classification of Interstitial Lung Disease. It is hypothesised that patients with IPF and CI will have decreased VO2peak compared to those with IPF but no CI.

**Methods**: Retrospective data was analysed from 16 participants with IPF, who performed an incremental ramp cardiopulmonary exercise test (CPET). Ethics approval for this study was granted by the Health Research Authority (IRAS #220189) following review by the South West (Frenchay) Research Ethics Committee (17/SW/0059). Chronotropic Response Index (CRI) was calculated as (HRmax-HRrest)/(220-age-HRrest), with a score ≤0.80 indicating CI. Independent t-tests were performed for comparison between those with and without CI. Pearson's correlation coefficient determined the relationship between CRI and VO2peak. Statistical significance was set at p≤ 0.05.

**Results**: A total of 6/16 (38%) participants with IPF met the criteria for CI. Mean CRI is lower in those with CI (0.55 ±0.23 vs 1.13 ±0.25, p=0.0005). Reduced VO2peak was found in people with CI, compared to without (13.0 ±3.8 vs 18.2 ±5.8 mL.kg-1.min-1, p≤ 0.05). A medium, but non-significant positive relationship between CRI and VO2peak was found (r=0.413, p=0.056).

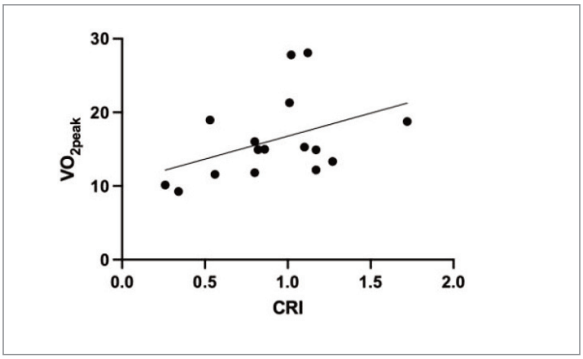


Figure 1. Scatterplot showing the relationship between $VO_{2peak}$ and Chronotropic Response Index (CRI) in Idiopathic Pulmonary Fibrosis (PEF) patients. (Pearson correlation, r=0.413, p=0.056)

**Conclusions**: CI occurs during maximal exercise in patients with IPF, and consequently demonstrated reduced VO2peak. Therefore, HR-based exercise prescription may need to be modified in IPF, due to presence of CI. Future studies should aim to investigate how HR-based exercise prescription can be modified for patients with IPF, who have CI.

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### P46

### Impact of cycling cadence on physiological response during a Cardiopulmonary Exercise Test

**Mr Chris Harding[1], Dr Benjamin Knox-Brown[1,2], Miss Shabana Chowdhury[3], Mr. Andrew Pritchard[3], Dr Joanna Shakespeare[4], Dr Karl P Sylvester[1,2]**

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**Introduction**: The impact of cycling at different cadences on cardiopulmonary exercise test (CPET) measurements is poorly understood, especially when looking at parameters that are relevant in the clinical setting. We aimed to investigate whether higher cadences of pedalling led to meaningful changes in physiological endpoints meaning cycling protocols could be more flexible to patients.

**Methods**: Study participants were recruited from healthy staff members working within three NHS trusts across England. At baseline, all participants completed a CPET at 60rpm, then subsequently completed CPETs at cadences of 70, 80, and 90rpm, allocated in a random order. To evaluate the mean differences in CPET measurements across the cadences, we used a one-way repeated measures ANOVA. We then performed post-hoc pairwise comparisons with Tukey correction to account for multiple testing.

**Results**: Data collection took place between the 19th of September 2023 and 9th of April 2024. 25 participants had complete data at each cadence. 48% (12 of 25) were female, with a median (IQR) age of 30 years (27-41). There was no significant difference in peak V̇O2 across the cadences. Maximum achieved work rate was significantly different across the cadences (p=0.0001). The highest wattage was achieved at 60rpm (221.2 watts ±71.4) and lowest at 90rpm (210.4 watts, ±77.2). End-exercise ventilation increased with increasing cadence (p=0.0129), with a mean of 97.6L/min (±28.3) at 60prm and 107.0L/min (±33.9) at 90prm. There was a significant difference in the cardiovascular slope (p=0.011), with mean cardiovascular slope 48.5 (±13.1) at 60rpm and 52.4 (±16.8) at 90rpm. Finally, there was a small but significant difference in test duration across the four cadences (P=<0.001), with the shortest duration (9.4 minutes) seen at 90rpm and the longest (10.1 minutes) at 60rpm. There were minimal differences in other CPET parameters.

**Conclusion**: In a healthy population, cycling cadence has little impact on estimates of overall cardiorespiratory fitness. However, higher cycling cadences appear to increase ventilatory demand and heartrate response to exercise and reduce maximum achieved work rate. This could have implications for CPETs in the clinical setting, where physiological responses to higher cadences may be more exaggerated.

### P49

### Impact of new Hypoxic Challenge Testing guidelines for children on long term supplemental oxygen

**Mrs Kirstie Rogers, Mrs Emma Fettes, Dr Paul Aurora**

*Great Ormond Street Hospital, London, United Kingdom*

**Introduction**: In 2022 the British Thoracic Society (BTS) published updated guidance (Coker RK, et al. Thorax 2022;0:1–22) on air travel for patients with respiratory conditions. These revised referral criteria for hypoxic challenge test (HCT), advising that patients on long term supplemental oxygen ($O_2$) should ideally have their in-flight $O_2$ flow determined by HCT.

**Aim**: To assess if performing HCT for patients on long-term $O_2$ changed management beyond previous guidance (Ahmedzai, S et al. Thorax 2011;66: i1ei30) which recommended doubling baseline flow during flight.

**Method**: All HCTs performed between March 2022 and December 2024 were reviewed. Patients were included if they were current users of $O_2$ (including those in nocturnal only $O_2$). Children in nocturnal only $O_2$ therapy started their test in air, provided baseline $SpO_2$ was greater than 92%. All other children started their test at their prescribed daytime flow. During the test the $O_2$ flow was increased in steps of 1L/min, with a starting point of 1L/min as this is the lowest flow widely available during flight.

**Results**: Three hundred and fifty-two HCTs were reviewed and 18 patients (11 female, mean±SD age 7.17±5.84yrs) met the criteria for inclusion. Thirteen out of 18 were in nocturnal $O_2$ therapy only. Two children had their baseline flow doubled during HCT. One had their baseline flow more than doubled, from 0.2L/min to 2L/min. Four children with starting flow <0.5L/min had their flow increased to 1L/min. Four children did not require any change in their $O_2$ flow. Five children in nocturnal only $O_2$ therapy and two with $O_2$ use only when unwell did not require $O_2$ during the test.

**Conclusions**: In this study, all children in 24-hr $O_2$ did not require any change in their $O_2$ flow during HCT. For children in nocturnal only $O_2$ the results were variable. Almost half of these children did not require $O_2$ therapy during HCT, creating uncertainty as to whether $O_2$ should be prescribed during flight. It is still uncertain whether the new guidance provides useful additional clinical information.

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### P50

### Transition to a physiologist-led cardiopulmonary exercise testing (CPET) service in a paediatric service and evaluation of outcomes two years post-implementation.

**Mrs Laura Jess**

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**Background**: In December 2022, a workforce planning strategy enabled the transition to a physiologist-led CPET service in the paediatric respiratory physiology service, NHS Lothian. Historically all CPETs were medically overseen, however following a change in workforce staffing model, an opportunity presented to implement a change in CPET service provision utilising appropriate, existing, advanced practice skill set.

There is now a requirement to evaluate effectiveness of this model for improvement to ensure the service continues to provide safe and accurate CPET provision long-term.

**Aims & Objectives**: The aims of this evaluation were:
1. To determine if a physiologist-led paediatric CPET service can provide safe, autonomous and accurate CPET provision.
2. To determine if a physiologist-led CPET service can create efficiencies in medical time.

**Objectives**
The objectives of this evaluation were therefore:
1. Evaluate the referral source of CPET referrals within the two-year period (identify the number of cross-specialism MDT sessions undertaken).
2. Identify reasons for stopping CPET tests.
3. Identify accurate ECG, safety and appropriate comments within interpretation.
4. Calculate the number of hours saved in medical time.

**Methods**: Data from young people that underwent CPET testing in the two-year period from implementation (January 2023 to December 2024) were evaluated. Referral source, reasons for stopping tests, ECG interpretation, safety comments and the number of hours saved in medical time were reported.

**Results**: Data from CPET tests performed between the two timepoints (n=126) are presented in Table 1:

**Conclusions**: The paediatric respiratory physiology service can safely and autonomously perform CPETs with accurate interpretation and escalation to appropriate MDT for clinical discussion. The implementation of a physiologist-led CPET service has saved 189 hours in medical time from overseeing the test in the two-year period.

| Parameter | Variable |
|---|---|
| Referral source | Respiratory medicine n=80<br>Spinal service n=32<br>Cardiology n=11<br>Gastrointestinal medicine n=1<br>External (chest wall service) n=2 |
| Number of MDT reporting sessions | Total number of MDT sessions n=126:<br>Respiratory medicine MDT sessions n=115<br>Cross-specialism MDT sessions n=11 (cardiology) |
| CPET test stopped by | Patient n=112<br>Physiologist n=14 |
| Reasons for stopping CPET (patient reason) | Leg fatigue n=83<br>Breathlessness n=27<br>Knee pain n=1<br>Completion of STEEP protocol n=1 |
| Reasons for stopping CPET (physiologist reason) | Failure to maintain cadence n=12<br>Safety reasons n=2 |
| ECG interpretation comments | ECG comments n=30:<br>Sinus arrhythmia n=9<br>Left ventricular hypertrophy n=1<br>Premature ventricular complexes n=5<br>Resting sinus tachycardia n=6<br>Sinus rhythm with right bundle branch block n=3<br>Sinus rhythm with right bundle branch block and premature ventricular complexes n=1<br>Sinus rhythm with multifocal ventricular complexes n=1<br>Sinus tachycardia, ventricular pacing and isolated premature atrial and ventricular complexes n=1<br>Third degree heart block n=1<br>RSR in V1 n=1<br>Prolonged PR interval with 2:1 conduction during exercise n=1 |
| Test safety and interpretation comments | Test stopped by physiologist due to significant desaturation n=1<br>Test stopped by physiologist due to change in conduction identified on ECG n=1<br>Tests performed with Cardiology Consultant supervision n=1<br>Tests performed with Cardiac Physiologist (pacing) supervision n=1<br>Tests performed with Cardiology Consultant guidance on lower limit of SpO2 n=1 |
| Number of hours saved in medical time | Number of hours = 189 hours |

Table 1

### P51

### Service Evaluation: The Modified Hypoxic Challenge Test

**Mrs Stephanie Brotherston[1], Dr Paul Aurora, Aidan Laverty, Rogers Kirstie, Riley Mollie, Dr Warraich Sara, Dr Martin Samuels**

*[1]Great Ormond Street Hospital, London, United Kingdom*

**Introduction**: Following a feasibility study between 2019-2021, we introduced a modified hypoxic challenge test (mHCT) to aid clinicians advising families and patients with complex needs, who used long term ventilation and planned air travel. We wanted to assess if the medical recommendations provided from the test were practical and used by the patient during air travel.

**Methods**: Patients who completed the test between November 2022 and October 2024 were contacted via telephone or asked in a follow-up consultation to complete a survey consisting of 7 questions that were asked by the medical team.

**Results**: We identified 38 patients (median age 6.8 years, range 3 m – 18 y) as eligible: 11 with neuromuscular disorders, 11 central hypoventilation disorders (e.g. CCHS,

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ROHHAD) and 16 with other diagnoses. The response rate was 30/38 patients and 21 of these took flights following mHCT. All patients followed the guidance, with 18 using NIV and/or supplemental oxygen. One patient reported respiratory difficulty during the flight but had an intercurrent illness at the time of flying. Whilst using ventilation, 48% required additional oxygen, the remainder using ventilation alone. Family feedback commented on gaining reassurance from the test.

| Post mHCT guidance Follow up Data | Answered survey (n) | Took a flight (n) | Did not fly (n) | NIV/Oxygen used in flight (n) | Followed recommendation for NIV / Oxygen use (n) | In-flight respiratory difficulty (n) |
|---|---|---|---|---|---|---|
| Total | 30 | 21 | 9 | 18 | 18 | 1 |

**Conclusion**: This service evaluation indicated the mHCT can inform the role of ventilatory support and reduce oxygen need during air travel, though it should be noted that this laboratory testing may not mirror an aeroplane environment. For patients and their families, mHCT helped travel planning, provided reassurance and had a cost benefit in reducing the need for supplementary oxygen.

**Reference**

Riley M et al Pediatr Pulmonol 2023; 58:88-97

### P52

### A comparison of Cardiopulmonary exercise testing in children with cystic fibrosis in the pre and post modulator therapy era

**Ms. Amy Hunt[1], Dr Ross Langley[2], Dr Phil Davies[2], Dr Anne Devenny[2], Dr Louise Thompson[2], Mr. Paul Burns[1]**

*[1]Department of Respiratory and Sleep Physiology, The Royal Hospital for Children, Glasgow, [2]Department of Respiratory Medicine, The Royal Hospital for Children, Glasgow*

**Introduction**: Cardiopulmonary exercise testing (CPET) has been used in cystic fibrosis (CF) as a prognostic indicator and has been shown to be more sensitive than spirometry. We have previously shown that CPET can be used as part of annual review and the majority of our patients had normal fitness levels (Weir et al Arch Dis Child 2017 102:440-44). However, with the introduction of modulator therapy - Elexacaftor/Tezacaftor/Ivacaftor (ETI), many CF patients may not be as compliant with treatment. Our aim was to compare CPET and spirometry results pre and post modulator therapy to determine if there were any differences.

**Methods**: This was a retrospective analysis of clinical data obtained from annual reviews of patients with CF who attended our clinic before and after ETI was introduced as a routine therapy. Spirometry and a CPET were performed (cycle ergometer using an incremental ramp protocol). Descriptive statistics were collected for all intervals of interest for both cohorts. A student non-paired T test was used to assess any significant difference in values pre and post modulator therapy.

**Results**: 35 sex matched patients in each group (19 female) were retrospectively analysed in both cohorts. The demographics, spirometry and CPET results are shown in the table below.

There was a significant increase in FEV1 from the pre ETI to post ETI group. The values for VO2peak % predicted, VO2/kg and Anaerobic threshold (AT) as a % of predicted VO2peak showed a significant decrease and breathing reserve (BR) significantly increased from pre to post ETI group.

| Parameter | Pre ETI | Post ETI | p-value |
|---|---|---|---|
| Age (years) | 11.2 (2.4) | 12.6 (2.1) | 0.013* |
| BMI z | 0.09 (1.1) | 0.12 (0.9) | 0.907 |
| FEV1 z | -0.85 (1.18) | -0.29 (1.07) | 0.043* |
| $VO_2$peak % pred | 103 (16) | 87 (14) | 0.000* |
| $VO_2$/kg | 41.2 (7.2) | 34.8 (7.2) | 0.000* |
| AT % $VO_2$peak | 54 (12) | 48 (11) | 0.015* |
| Peak HR (bpm) | 187 (9) | 186 (9) | 0.675 |
| Breathing Reserve (%) | 21 (18) | 37 (15) | 0.000* |

Mean (SD), * denotes statistical significance

**Conclusions**: Our CF patients have shown a small but significant improvement in FEV1 since starting ETI. However, they have exhibited a large decline in fitness levels as shown by the reduction in VO2peak % predicted, VO2/kg, AT % VO2peak and increased BR. It is hypothesised that the reduction in aerobic fitness may be due to a reduction in physical activity levels in our CF population as a result of feeling better whilst on ETI.

### P53

### Switching from GLI 2012 to GLI global 2022 reference equations changes spirometry interpretation in children

**Mr. Mark Tuazon, Mrs Mollie Riley, Mrs Emma Fettes, Dr Paul Aurora**

*Great Ormond Street Hospital, London, United Kingdom*

**Introduction**: The Global Lung Function Initiative (GLI) 2022 reference values are a race neutral approach to spirometry interpretation. We aimed to determine the impact of switching from GLI 2012 to GLI 2022 on spirometry results in patients seen at Great Ormond Street Hospital for Children (GOSH).

**Methods**: A retrospective analysis of spirometry performed between 2020 and 2023. Results were interpreted and compared using both GLI 2012 and GLI 2022 to ARTP standards (LLN <-1.64z-score). Mean results

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between methods, and normal/abnormal classification were compared for white children and black children.

**Results**: Spirometry results were analysed in 3,254 patients aged (mean [SD]) 11.5[3.8] years. 54.5% were male. Patients/carers self-reported race using the GLI 2012 groups and at time of test as White (2,219, 68.2%), Black (512, 15.7%) and Other (523, 16.1%).

When using GLI 2012, there were 1,183 (36.4%) results < LLN, compared to GLI 2022 with 1,117 (34.3%).

Black children had lower spirometry z-scores with GLI 2022 than with GLI 2012 (FEV1: -1.54 vs -0.83, difference -0.71, p<0.01; FVC: -1.39 vs -0.65, difference -0.75, p<0.01).

61 (11.9%) Black subjects whose results were classified as normal by GLI 2012 were reclassified as restrictive by GLI 2022. There was no change in the number of tests classified as obstructive.

White children had higher spirometry z-scores with GLI 2022 than with GLI 2012 (FEV1: -0.68 vs -1.1, difference 0.40, p>0.01; FVC: -0.47 vs -0.90, difference 0.437, p<0.01. 118 (5.3%) White subjects whose results were classified as restrictive by GLI 2012 were reclassified as normal by GLI 2022. There was virtually no change in the number of tests classified as obstructive.

**Conclusion**: Interpretation of spirometry changes when switching from GLI 2012 to GLI 2022.

### P54

### Alternative protocols to derive Scond from paediatric multiple breath washout

**Ms. Mollie Riley[1,2], Dr Per Gustafsson[3,4], Dr Gwyneth Davies[1,2], Dr Paul Aurora[1,2]**

*[1]Heart and Lung Directorate, Great Ormond Street Hospital for Children NHS Foundation Trust, London, United Kingdom, [2]UCL Great Ormond Street Institute of Child Health (UCL GOS ICH), London, United Kingdom, [3]Department of Pediatrics, Institute of Clinical Sciences, The Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden, [4]Lung function Research Laboratory, Central Hospital, Skövde, Skövde, Sweden*

**Introduction**: Multiple breath washout (MBW) is an inert gas washout test that measures ventilation distribution inhomogeneity. Convection dependent "Scond" and diffusion-convection dependent "Sacin" inhomogeneity indices are derived from the progression of concentration normalised phase III slopes (SnIII) in MBW and are used to reflect conductive and acinar airway impairment. There is limited evidence on the influence of alternative methods for deriving Scond from MBW tests in children across a wide age range.

**Aim**: To compare different protocols for deriving Scond in children.

**Methods**: Mass spectrometer (AMIS 2000) SF6-MBWs in healthy children and children with Cystic Fibrosis (CF) were reanalysed using in-house LabView® software. Children with advanced lung disease (lung clearance index ≥10) were excluded. Scond was derived as the linear increase in the SnIII between 1.5 and 6 turnovers. The SnIII were modified for each breath by eye. Three protocols were used for deriving Scond: A) all breaths with acceptable SnIII pooled across 3 runs as suggested by the ERS/ATS consensus statement (Robinson, et al ERJ 2013), (B) all breaths with acceptable SnIII, mean of 3 runs, similar to commercial software (ExhalyzerD® Eco Medics AG) and C) all breaths irrespective of SnIII quality, mean of 3 runs. ULN was defined as +1.96SD.

**Results**: MBW tests in 100 children (3-17yrs, 50 with CF) were reanalysed. Scond was similar using protocol A and B in health (mean±SD 0.020±0.010 vs 0.021±0.010) and in CF (0.059±0.030 vs 0.059±0.030). Bland-altman analysis found a low bias (0.0003) and narrow limits of agreement (LOA), -0.0024 to 0.0029) between A and B. Scond was higher using B than C in CF (0.059±0.030 vs 0.053±0.034, p<0.05), but not in health (0.020±0.010 vs 0.018±0.016). Wide LOA were seen between B and C, -0.024 to 0.031. Proportion of children with CF and abnormal Scond was higher with B than C, 70% vs 42%. Intra-test repeatability was lower for B than C, 0.009±0.005 vs 0.023±0.023, p<0.05 in health. A similar result was found for CF.

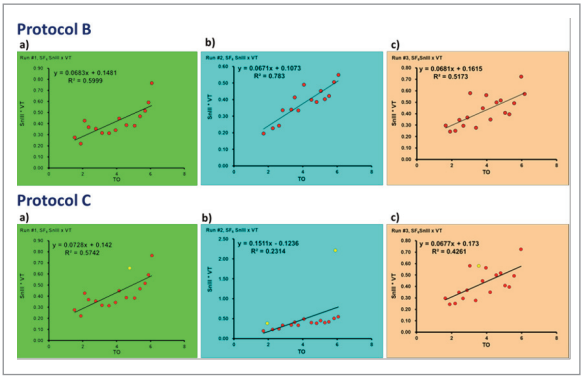


Figure 1. Six plots of $Sn_{III}$ vs turnover (TO), corresponding to three trials of a MBW (trial 1 in green (A), trial 2 in blue (B), trial 3 in orange (C), and two different protocols (B&C) used for deriving $S_{cond}$. The three plots on the top row are using Protocol B and the three on the bottom are using Protocol C; the latter includes yellow markers/data points to represent the inclusions of poor quality $Sn_{III}$/breaths.

**Conclusion**: Different protocols for deriving Scond produce different results from the same MBW. The process of rejecting poor quality SnIII is essential for producing reliable Scond in children.

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### P55

### Deriving airway dead space from multiple breath washout

**Ms. Mollie Riley[1,2], Dr Per Gustafsson[3,4], Dr Gwyneth Davies[1,2], Dr Paul Aurora[1,2]**

*[1]Heart and Lung Directorate, Great Ormond Street Hospital for Children NHS Foundation Trust, London, United Kingdom, [2]UCL Great Ormond Street Institute of Child Health (UCL GOS ICH), London, United Kingdom, [3]Department of Pediatrics, Institute of Clinical Sciences, The Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden, [4]Lung function Research Laboratory, Central Hospital, Skövde, Skövde, Sweden*

**Introduction**: Airway dead space, as we measure it, is the volume between the airway opening and the numerous airway-alveolar interfaces of the lung. The multiple breath washout (MBW) derived lung clearance index (LCI) is influenced by both series (airway; VDaw) and parallel dead space volume (VD). The Fowler equal area method (VDawF) is the best-known derivation method for VDaw. The Langley (VDawL) and Cumming (VDawC) methods are derived from the cumulative expired gas vs 40-80% of expired volume using linear or quadratic regression. There are very few published data (Tang et al. BJA 2007; 98(6), 828-834) comparing the methods and no studies have included children.

**Aim**: To compare three different methods for deriving VDaw in health and disease.

**Methods**: Approvals were obtained for re-analysis of SF6 MBW mass spectrometer tests collected in 37 healthy adolescents (≥12years) and 37 adolescents with Cystic Fibrosis (CF). Using the SF6 signal, VDawF, VDawL, and VDawC were derived and compared.

**Results**: Repeated ANOVA revealed significant differences between the methods in both health and CF ($p<0.001$). Pairwise comparisons showed a significant mean difference between VDawC and VDawF (-0.014L, $p<0.0001$), VDawC and VDawL (-0.011L, $p<0.0001$) and VDawF and VDawL (0.003L, $p=0.012$) in health. Similar results were also observed in CF but VDawF and VDawL did not differ. The difference between VDawL and VDawC (VDawL - VDawC) correlated with the normalised phase III slope of the first breath and the LCI, $r = 0.75$ (Figure 1) and 0.69 respectively (both $p<0.001$). The same relationships were not observed with VDawF - VDawC.

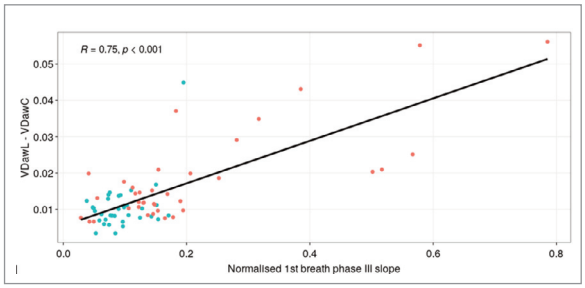


Figure 1. Correlation plot of the difference between VDaw derived using the Langley method and VDaw derived using the Cumming method (VDawL - VdawC) vs the normalised phase III slope of the first breath ($Sn_{III}$*VT). The blue circles are healthy adolescents, and the red are those with CV

**Conclusions**: VDaw measured by expired gas concentration is a moving object as different results are produced depending on the method of its derivation. VDawC is smaller than VDawL and VDawF. MBW operators reliant on commercial MBW software, which reports VDawF and VDawL, should acknowledge that VDawL is sensitive to changes in the shape of the expirogram and thus, ventilation inhomogeneity.

### P57

### The Impact of New NICE Guidelines on Paediatric Asthma Diagnosis in a GP Choose and Book Clinic

**Miss Emma Hesketh, Miss Laurie McCartney, Mrs Debbie Large, Mrs Nicola Rimmer, Mr. Philip Lawrence**

**Introduction**: NICE guidelines for asthma diagnosis, monitoring and chronic management were updated in November 2024 (National Institute for Health and Care Excellence, 2024). NICE recommends to start with Fractional Exhaled Nitric Oxide (FeNO) and if elevated (≥35ppb) asthma can be diagnosed. If FeNO is below 35ppb or is unavailable, Spirometry with bronchodilator reversibility (BDR) is recommended. A significant BDR is defined as ≥12% increase in $FEV_1$ or ≥10% increase in predicted $FEV_1$. NICE recommends that patients with normal baseline spirometry should still have BDR. However, concerns have arisen regarding the feasibility of spirometry with BDR following normal spirometry, due to the low number of patients diagnosed with asthma as a result and the increased cost in time and consumables.

**Methods**: Audit data was collected from the GP Choose and Book (CAB) service at Alder Hey, Liverpool, since November 2024. FeNO was assessed using a NIOX VERO (NIOX group plc, Oxford) and spirometry was performed using the Vyaire Vyntus ONE (Vyaire Medical, Mettawa, IL, USA).

**Results**: 125 (66 male) patients performed FeNO and Spirometry with BDR if indicated. 46 (36.8%) had elevated FeNO. 71 (56.8%) patients had normal FeNO and normal baseline Spirometry. 15 (12%) patients were on medication, which may indicate well controlled asthma. 56 (44.85%) patients had BDR of which 5 (4%) patients had significant reversibility. 8 (6.4%) patients had an obstructive ventilatory defect on baseline, of which 2 (1.6%) patients

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had significant reversibility. 4 (3.2%) patients with obstruction did not reach reversibility significance, however, their lung function was normal post BDR.

**Conclusions**: FeNO is a powerful diagnostic tool with 78% of asthma diagnoses made were due to elevated FeNO. BDR spirometry was performed in 79 patients, of which only 7 patients (8.9%) had significant BDR. Spirometry with BDR has significant resource and environmental implications, such as spacer and bronchodilator usage for each patient and increased appointment length, ultimately reducing the number of patients tested per clinic. Spirometry with BDR may not be feasible considering the low number of diagnoses. An alternative approach could be to only perform BDR when an obstructed pattern is present on baseline spirometry.

### P59

### Implementation of the Forced Oscillation Technique into Spirometry Clinics: A Service Level Evaluation

**Miss Madison Geeves[1], Dr Michael Hughes[1], Miss Phoebe Wan[2], Miss Elise Mercer[1], Miss Megan Leonard[1], Mrs Zoe Ford[1], Dr Harry Griffin[1]**

*[1]Hampshire Hospitals NHS Foundation Trust, Basingstoke, United Kingdom, [2]Curtin University, Perth, Australia*

**Introduction**: Spirometry is routinely used to assess patients with suspected or confirmed airway disease. However, it has been criticised for its potential insensitivity in detecting early or mild airways disease and some patients struggle to meet the required technical standards. The use of the Forced Oscillation Technique (FOT) has been proposed to address these concerns but remains relatively unused in clinical practice. This service level evaluation aimed to assess the potential benefits of incorporating FOT into routine spirometry testing within a respiratory physiology outpatient service.

**Methods**: Patients referred for spirometry ± reversibility testing at Hampshire Hospitals NHS Foundation Trust were also assessed using FOT (ResMon Pro Full V3). Abnormal spirometry (FEV1/VCmax z-score <-1.64), abnormal FOT parameters (total resistance; Rrs at 5 Hz > upper limit of normal and/or reactance; Xrs at 5 < lower limit of normal) and a positive bronchodilator response (BD; >200 mL AND 12% for FEV1; −32% for Rrs 5 Hz and/or +44% for Xrs 5) were defined accordingly.

**Results**: Anonymised data for 119 patients who attended clinic between April 2023 and June 2024 were analysed and grouped as follows; normal spirometry and normal FOT (n=56), abnormal spirometry and abnormal FOT (n=23), normal spirometry but abnormal FOT (n=10), and abnormal spirometry but normal FOT (n=30). Reversibility testing was performed in 19 patients. Of these, six had a positive BD response on spirometry but only one also demonstrated a positive BD response on FOT. One patient demonstrated a positive BD response on FOT but a negative response on spirometry.

**Conclusions**: Unexpectedly, 57% of patients with airflow obstruction on spirometry had normal FOT results (total Rrs and Xrs at 5 Hz) and only 17% of patients with a positive BD response on spirometry demonstrated a positive response on FOT. These preliminary findings suggest that if performed as an alternative to spirometry, FOT may fail to identify abnormalities in patients with potential airflow obstruction. Further analysis will be carried out to classify the severity of airflow obstruction, assess additional FOT parameters including within-breath abnormalities, and attempt to understand the discrepancies seen in this evaluation between the two tests.

### P61

### A comparative analysis of physical control alveolar volume data between a manual calibration syringe and a ventilated syringe

**Miss Supriya Pokhrel[1], Miss Lauren Kimberley[1], Mrs Jessica Swan[1], Mr. Mark Unstead[1], Mr. Darren Murray[2]**

*[1]Royal Berkshire Hospital, Reading, United Kingdom, [2]Vyaire Respiratory Diagnostics is now Jaeger Medical, Basingstoke, United Kingdom*

**Introduction**: Recent guidance suggests a daily physical control test should be performed using a 3L syringe (ARTP, 2020). In accordance, with supplier guidance this is performed locally with a syringe with integrated ventilation.

The aim of this study was to assess if physical control readings for transfer factor could be performed with regular manual calibration syringe.

**Method**: A TLCO verification (n=91) was performed using a 3L calibration (3LC) and a ventilated 3L syringe (3LV). The mean and difference was calculated between 3LC and 3LV. Local acceptable VA ranges for either syringe were set at (2.85 – 3.15L).

A Bland-Altman analysis was conducted to assess the agreement between VA values obtained from the 3LC syringe and 3LV syringe, by evaluating the mean difference and the limits of agreement.

**Results**: The median 3LC syringe VA value was 2.94 (IQR = 2.92-2.95), and the median 3LV syringe VA value was 2.92 (IQR = 2.89-2.97). The coefficient of variation (CV) for

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the 3LC VA was 0.90, compared to a CV for the 3LV of 1.83.

The median 3LC VIN value was 2.99 (IQR = 2.98-3.01), and the median 3LV VIN value was 3.00 (IQR = 2.95-3.02). The CV for the 3LC syringe VIN was 1.04, compared to a CV for the 3LV syringe of 1.79.

A Wilcoxon Signed Ranks test indicated no statistically significant differences in VA values between 3LC and 3LV (Z=-1.177, p = 0.239).

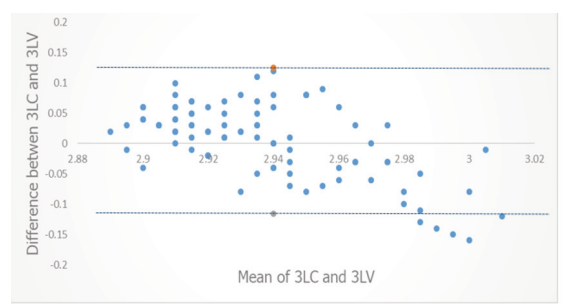



Figure 1. The figure shows Bland-Altman graph showing the difference between 3LC and 3LV syringes

**Conclusion**: This data would suggest there is no significant difference between values for VA between either syringe. A non-vented calibration syringe can be used as an addition to a fan ventilated model for VA QC checks. Laboratories should set their own local tolerance levels when using different types of verification syringe.

### P64

### Revisiting Validity in Eucapnic Voluntary Hyperpnoea (EVH) Testing: A Case Series Highlighting the Utility of a Flexible Ventilatory Threshold

**Mr. Andrew Eaton, Dr William Ricketts, Mr. Tremayne Woolliscroft**

*Barts Health NHS Trust, London, United Kingdom*

**Introduction**: Eucapnic voluntary hyperpnoea (EVH) is a validated surrogate for exercise in the objective diagnosis of exercise-induced bronchoconstriction (EIB) (Figure 1). However, its validity traditionally depends on achieving a minimum hyperventilation target, defined as ventilation (VE) ≥80% of maximum voluntary ventilation (MVV).

This strict threshold can lead to invalid tests for individuals unable to meet it due to physiological or technical limitations. This case series explores the use of a novel validity criterion (VE ≥60% of MVV) in three diverse participants, demonstrating its ability to preserve diagnostic integrity.

**Methods**: Three participants (M:2, F:1; aged 17–27 years) underwent EVH testing at using a Jaeger CPX system. Hyperventilation breath by breath data was captured continual for six minutes. Entrained directly into the circuit was a gas mix consisting of 21% O2 5% CO2 and 74% Nitrogen.

Baseline and post-EVH $FEV_1$ values were recorded at 3,5,7,10,15,20 minutes. Post 20-minute time a 2.5mg Salbutamol nebuliser was administered.

VE as a percentage of MVV was calculated, with test validity determined using traditional (≥80%) and novel (≥60%) thresholds.

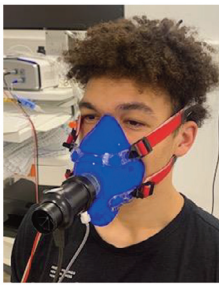
**Results**:

Subject 1 (M, 27 years): VE = 54.54% MVV, 7.6% $FEV_1$ reduction (normal response).

Subject 2 (M, 17 years): VE = 76.20% MVV, 8.9% $FEV_1$ reduction (normal response).

Subject 3 (F, 19 years): VE = 65.15% MVV, 13% $FEV_1$ reduction (mild airway hyperresponsiveness).

**Conclusion**: For participants with suboptimal ventilatory performance, such as those with lower fitness levels achieving 80% of MVV may not be feasible, leading to the invalidation of their tests. Subject 1, for instance, achieved only 54.54% of MVV yet demonstrated a normal post-test $FEV_1$ reduction of 7.6%, indicative of a valid negative response. Similarly, Subject 3 achieved 65.15% of MVV, with a 13% $FEV_1$ reduction consistent with mild airway hyperresponsiveness. Both cases would have been excluded under the traditional criteria, potentially delaying or misdirecting clinical care.



Expanding test validity criteria balances methodological rigour with practical applicability. These findings emphasise the need for further research to evaluate the impact of ventilatory thresholds on EVH outcomes across diverse populations and settings. Additional studies are warranted to confirm broader applicability.

### P65

### Validating a model for predicting exertional hypoxaemia in patients with interstitial lung disease.

**Mr. Bryn Williams[1], Dr Rachel Lowry[1], Professor Dilwyn Marple-Horvat[2], Dr Helen Parfrey[1], Dr Karl Sylvester[1]**

*[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]Manchester Metropolitan University, Manchester, United Kingdom*

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**Introduction**: For patients with interstitial lung disease (ILD), a DeOX score, integrating resting SpO2 and TLCO % predicted (0-2; 0=SpO2 >95% and TLCO >40%; 1=SpO2 ≤95% or TLCO ≤40%; 2=SpO2 ≤95% and TLCO ≤40%) has been proposed to predict exertional hypoxaemia (SpO2 ≤88%) risk during 6-minute walk tests (6MWT) (Alfieri, V., et al. ERJ 2020; 55(2): 1901681).

**Methods**: A retrospective analysis of ILD patients, attending a tertiary care ILD referral centre, was undertaken to validate the predictive value of the DeOX score. Model performance was assessed using odds ratios (derived from unadjusted logistic regression), AUROC curve analysis, and 2x2 contingency tables (considering a DeOX =1 as both a positive and negative result).

**Results**: A total of 392 ILD patients (65.5% male, age 73-years-old [IQR 62.3-78.0], 31% never smokers) performed TLCO and 6MWT on the same day. Of these, 32% demonstrated an SpO2 ≤88% during 6MWT, meeting criteria for ambulatory oxygen therapy (AOT). The odds ratio for 6MWT SpO2 ≤88% was 6.8 (95% CI 4.0-11.6) when DeOX =1, increasing to 60.8 (95% CI 20.5-180.3) when DeOX =2.

Both TLCO % predicted (AUROC 0.84 [95% CI 0.80-0.88]) and resting SpO2 % (0.84 [0.80-0.88]) demonstrated excellent ability to differentiate patients with exertional hypoxaemia, total DeOX (0.79 [0.74-0.84]) performed equally. When considering DeOX =1 a positive result, sensitivity 71.2% (95% CI 62.9-78.7), specificity 82% (77.1-86.3) and negative predictive value 85.9% (81.3-89.8).

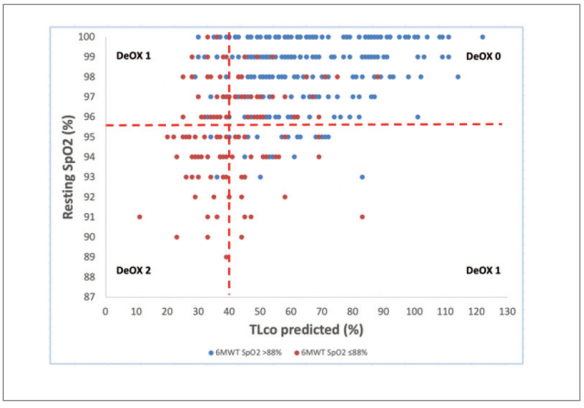


Figure 1. TLco predicted versus resting $SpO_2$ for all patients; blue dots represent absence of exertional hypoxaemia on 6MWT (defined as $SpO_2$ ≤88%); red dots represent presence of exertional hypoxaemia

**Conclusions**: Our data confirms the DeOX score's predictive ability for patients with ILD and supports usage as a simple screening and triaging tool. When DeOX ≥1 formal AOT assessment is recommended, with the urgency increasing as DeOX increases.

### P66

### Adherence to home spirometry in lung transplant recipients: a real-world study

**Mr. Bryn Williams[1], Dr Ben Knox-Brown[1], Dr Karl Sylvester[1], Miss Rebecca Borton[2], Dr Caroline Patterson1**

*[1]Royal Papworth Hospital NHS Foundation Trust, Cambridge, United Kingdom, [2]PatientMPower, Ireland*

**Introduction**: The early detection of allograft dysfunction via good quality home spirometry allows prompt intervention and may improve lung transplant (LTx) outcomes.

**Methods**: A retrospective analysis of 162 adult LTx recipients examined the adherence to home spirometry, quality assurance, and patient-initiated response to ≥10% decline in FEV1.

Adult LTx recipients received portable handheld spirometers (Spirobank Smart, MIR) linked to an eHealth application (patientMpower) and were requested to perform home spirometry daily for the first-year post-transplant, reducing to weekly when deemed clinically appropriate. Patients were asked to contact the transplant team via email or telephone if FEV1 (L) declined ≥10% compared to their most recent measurement, reproduced on consecutive days. The clinical team reviewed the eHealth application at each outpatient appointment and if alerted by patients. Between appointments compliance with home spirometry and quality assessment was not formally monitored.

Percentage adherence to daily and weekly spirometry was calculated, and medical records used to identify the response to declines in FEV1 ≥10%.

**Results**: 26 patients had the spirometer during the first-year post-transplant, adherence to daily spirometry was a median (IQR) of 15.7% (6.3-40.7); adherence to weekly spirometry was 39.3% (18.1-81.0). 136 patients received the spirometer after the first-year post-transplant, adherence to weekly spirometry was 31.4% (10.2-61.6).

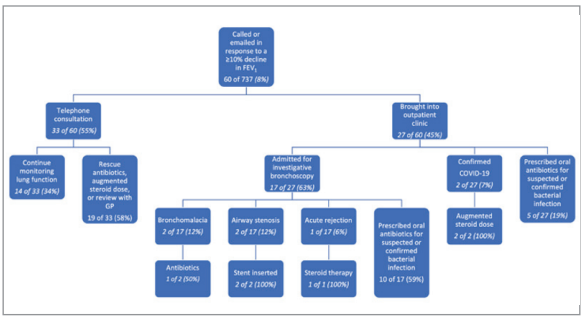


Figure 1. Outcomes following the reporting of a ≥10% decline in $FEV_1$ via telephone or email. Three patients brought into clinic had no change to treatment. Two patients admitted for bronchoscopy had no change to treatment

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ArtiQ software reported 49% (6,770 of 13,702) of all spirometry measurements were technically acceptable (Grade A-C).

Five percent of all spirometry measurements (737 of 13,702) resulted in a drop in FEV1 ≥10%, with 8% (60 of 737) of drops being reported by patients.

**Conclusions**: In a real word setting, we found poor patient adherence to home spirometry and the reporting of a ≥10% decline in FEV1. When patients did report a ≥10% decline in FEV1, a change in treatment or management resulted in most cases. Future work should investigate the patient reported barriers and facilitators to adherence and examine interventions designed to increase adherence and improve the quality of spirometry measurements. This approach, combined with the introduction of automated alerts following a ≥10% decline in FEV1, could facilitate earlier intervention and improve LTx outcomes.

### P70

### Evaluating the viability of triaging Pulmonary Function Tests (PFTs) and consolidating current appointment types at Sunderland Royal Hospital

**Mrs Katie Rutterford, Mr. Peter Muse-Ray**

*South Tyneside And Sunderland NHS Foundation Trust, Sunderland, United Kingdom*

**Introduction**: Recent guidance recommends triaging requests for pulmonary function tests (PFTs) prior to booking (GIRFT 2024), but this had not yet been feasible in our service due to clinical pressures. This audit was performed to evaluate the viability of triaging for our service as well as consolidating PFT appointment types. The aims were:

1) Were patients clinically indicated for all the tests they had been requested to do?

2) Were 34 PFT appointment types necessary when all combinations were taken into consideration?

**Methods**: PFT requests on the waitlist between November 2023 and February 2024 were 'triaged' by a specialist respiratory physiologist (band 6 or above) to ensure the requested tests aligned with clinical guidelines e.g. NICE, and patient history. Any discordance was queried directly with the referrer. Appointment type utilisation was calculated for the previous 12-month period, and the previous 4 years.

**Results**: 43 referrals were queried due to deviation from clinical guidelines, and 22 responses were received (51.16 % response rate). 19 of those (86.36 %) led to a change in the combination of PFTs asked for. Overall, this saved 11.33 hours of testing time from the original requests.

9 appointment types were not utilised in the previous 12-months, with a further 9 utilised <10 times. Within those 18 types, half of them were performed <10 times in the previous 4 years also.

| Appointment Types |
|---|
| 6MWT |
| Airways resistance |
| COHb |
| Bronchial challenge |
| FeNO / Bronchial challenge |
| FeNO / Full PFTs |
| FeNO / Full PFTs / 6MWT |
| FeNO / Full PFTs / Bronchial challenge |
| FeNO / Full PFTs / Positional spirometry |
| FeNO / Full PFTs / Reversibility |
| FeNO |
| FeNO / Spirometry |
| FeNO / Spirometry / 6MWT |
| FeNO / Spirometry / Reversibility |
| FeNO / Spirometry / Reversibility / 6MWT |
| Full PFTs / 6MWT |
| Full PFTs / Bronchial challenge |
| Full PFTS / Mouth Pressures |
| Full PFTs / Mouth Pressures / Positional spirometry |
| Full PFTs / Positional spirometry |
| Full PFTs / Reversibility |
| Full PFTs |
| Mouth Pressures |
| Positional spirometry |
| Positional spirometry / Mouth Pressures |
| Pre-Flight Oxygen Assessment |
| Shuttle Walk test |
| Spirometry |
| Spirometry / Reversibility |
| TLCO |
| TLCO / Reversibility |
| TLCO / 6MWT |
| Volume Loop |
| Volume Loop / Reversibility |

| Appointment Types |
|---|
| 6MWT |
| Bronchial challenge |
| FeNO / Bronchial challenge |
| FeNO / Full PFTs |
| FeNO / Full PFTs / Reversibility |
| FeNO |
| FeNO / Spirometry |
| FeNO / Spirometry / Reversibility |
| Pre-Flight Oxygen Assessment |
| Full PFTs / 6MWT |
| Full PFTs / Muscle Function Test (must specify) |
| Full PFTs / Reversibility |
| Full PFTs |
| Muscle Function Test (must specify) |
| Spirometry |
| Spirometry / Reversibility |
| TLCO / 6MWT |

Figure 1. Original PFT appointment list (34) on the left, with the new PFT appointment list (17) on the right after performing/this audit showing the need to reduce the options available.

**Conclusions**: There is value in triaging referrals, as due to the testing time saved, this indirectly reduced the time patients waited for testing. Variation in referral patterns for similar conditions e.g. asthma, demonstrated the need for a standard operating procedure to aid referrers in selecting the appropriate PFT combination. Assessing the usage of appointment types showed there is reason to reduce the options available due to under-use; and may have contributed to the variation in referrals seen. Lastly, protected administrative time was created to facilitate regular triaging.

### Reference

1. Further Faster Respiratory and sleep medicine Handbook. Available at: FF Handbook - Respiratory Master December 2024 - Getting It Right First Time - FutureNHS Collaboration Platform [Accessed 3 Jan. 2025, page 13].

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### P71

### Inter- and Intra-Session Variability of the VitaloROV+ and VitaloLAB Pulmonary Function Testing Equipment in Healthy Volunteers

**Ms. Tasmin Sharley, Mr. Joe Kirwan, Mr. Ross Warner, Mr. Frank Keane, Mrs Claire Cherry**

*Vitalograph Ltd, Buckingham, United Kingdom*

**Introduction**: The VitaloPFT is a line of pulmonary function testing (PFT) equipment, featuring the laboratory-based VitaloLAB model and the portable VitaloROV+ model. The current study evaluated the inter- and intra-session performance of the VitaloLAB and VitaloROV+ PFT systems, by measuring variability in test results for diffusing capacity of the lungs for carbon monoxide (DLco).

**Methods**: Eight healthy male and female volunteers were invited to participate in the study. Included subjects provided DLco readings, collected using two different VitaloLAB devices and two different VitaloROV+ devices. All tests were overseen by a single operator, with test sessions conducted in the morning or at lunchtime over a period of 8 days. Daily calibration was performed for all four devices, along with biological and mechanical quality control testing. Variability across repeated measurements was assessed using the coefficient of variation (CoV), with a target CoV of 3.1% based on prior research (Punjabi et al. Chest 2003; 123: 1082–9).

**Results**: Complete data were available for five test subjects, who each provided 16 separate DLco readings, totalling 80 individual data points. Data for inter- and intra-session variability for the VitaloLAB and VitaloROV+ PFT systems are shown in Table 1. The majority of CoV values were 3.1%, with all remaining values exceeding this target by 0.11–2.17%. DLco values of <0.5 mL/min/mmHg were recorded during quality control testing using a 3L syringe, consistent with ERS/ATS performance standards. Results of simulation testing verified that DLco measurements obtained using the VitaloROV+ and VitaloLAB systems were accurate per the manufacturer's specifications.

**Conclusions**: Inter- and intra-session testing indicate that the VitaloPFT series — comprising the VitaloROV+ and VitaloLAB systems — provide consistent and comparable results over successive manoeuvres, reducing the need for multiple tests where devices are located in different departments or institutions. The authors recommend that inter- and intra-device testing be performed by all device manufacturers to provide users with confidence in their patients' results. Additional analyses in a larger population of test subjects over a longer time period are warranted.

| CoV | Subject 1 (Male) | Subject 2 (Female) | Subject 3 (Male) | Subject 4 (Female) | Subject 5 (Female) | Biological QC (Male) |
|---|---|---|---|---|---|---|
| VitaloROV+, machine A | 1.97% | 2.11% | 1.49% | 0.60% | 0.86% | 2.26% |
| VitaloROV+, machine B | 2.73% | 1.63% | 0.58% | 3.28% | 0.76% | 2.62% |
| VitaloLAB, machine A | 3.21% | 0.73% | 0.92% | 1.68% | 0.71% | 2.66% |
| VitaloLAB, machine B | 4.33% | 5.27% | 3.10% | 1.16% | 0.53% | 1.66% |
| VitaloROV+, machine A vs machine B | 2.30% | 3.11% | 0.99% | 2.08% | 1.67% | 2.50% |
| VitaloLAB, machine A vs machine B | 4.18% | 3.23% | 3.28% | 1.89% | 0.77% | 2.16% |
| All equipment | 3.20% | 3.34% | 2.25% | 2.10% | 2.59% | 2.36% |

CoV, coefficient of variation; DLco, diffusing capacity of the lungs for carbon monoxide; QC, quality control

Table 1. Intra- and inter-session variability in DLco measurements obtained using VitaloPFT pulmonary function testing equipment (test subjects, n=5; biological QC, n=1)


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