April 2020 VOLUME 21, ISSUE 1

ARTP

Association for Respiratory Technology & Physiology

Inspire

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FIRST WORD

VOLUME 21, ISSUE 1. APRIL 2020

Welcome to the Spring issue of Inspire, which obviously comes at a time of unprecedented upheaval within healthcare and society as a whole. At the time of writing, myself and fellow physiologists at our Trust have just attended a clinical refresher session and volunteered to shadow on wards to see if they can assist in any way during the Coronavirus crisis. Personally I have been impressed by how eager colleagues have been to volunteer and I am sure it will be likewise for you all across the country. I wish you the best of health. With the future unknown, items such as patient cancellations, rebooking dates, Referral To Treatment deadlines all seem less important in comparison to how we can use our skill sets to assist in healthcare. You will also be aware that ARTP have recently published COVID-19 guidelines.

Our knowledge about COVID-19 was probably just starting when we had our January conference, which was better organised than ever (if possible!) and featured excellent research presentations and speakers. All abstracts can be found here and I know that several of the sleep-related abstracts are featured in more detail in the new S-NEWS. Suffice to say that I have my favourite! ARTP have also put the oral presentations on the website.

We have two excellent articles from ARTP conference grant winners, addressing differences between ECCS and GLI predicted values and a timely overview of the various hypoxic challenge tests available today. Fresh Air, from ARTP Research, showcases the intriguing concept of Volatile Organic Compounds (VOCs, to those in the know) in exhaled breath. We have the regular round-up of the ARTP forum, 'Top Forum', which is busier and more colourful than ever. 'On the Blower' has updates from some of the manufacturers you may have missed during the conference and is an excellent resource with hyperlinks to all the suppliers. 'OTB' also features a special informative (in many ways) article from Alan Moore on Clean Machines.

The sharp-eyed among you will have noticed the absence of 'Refresher' this issue. This was an attempt to compile social media posts or journal articles since the previous issue – rather like 'Top Forum' for social media. If **you** would like to take this on for a future issue of Inspire then please start collecting the posts/articles now in time for the next issue and let me know by contacting me at Inspire@artp.org.uk. I am also looking for a new Deputy Editor (duties not too taxing, honestly) so likewise, please let me know if you would like to help.

I am hoping this issue is error-free and thanks to Editorial for their help although this has been a little more rushed than usual, for obvious reasons.

I hope you enjoy this issue and wish you well until the next one, expected in August.

Aidan Laverty

A WORD FROM THE CHAIR

Julie Lloyd

ARTP Honorary Chair

Hello and welcome to this, our post-Conference edition of Inspire. Usually this would be the time where we would celebrate the success of our recent Conference in Birmingham and look to the future. However, we all find ourselves in circumstances that none of us has experienced before in our working lives and the thought of looking to the future is a somewhat daunting prospect because of the COVID-19 Pandemic.

I will keep this message brief as I'm sure that none of you have the time at the moment to pore through anything that isn't essential. Most of you by now have made detailed plans for your service and your team members and looked to where your skills can be used elsewhere in your organisations. A significant number of you will already be working in ways that you would not have imagined a few short months ago, developing new skills and learning to work on wards and in other areas across your Trusts. Those of you with skills in non-invasive ventilation will find your skills in high demand in the upcoming months, and all of us as healthcare scientists will adapt and do what is required to make a difference.

ARTP has been at the forefront of getting current information about COVID-19 circulated as quickly as possible and has worked closely with other respiratory professional groups such as BTS and PCRS to make this as applicable as possible. Please let us know if there is anything we can do as a professional body to support you further.

I promised you this would be brief so I look forward to writing my next introduction when we have all come through the other side of the worst of the COVID-19 Pandemic. The enormity of this event will permanently change all of us in some way and taking care of ourselves as well as our patients is essential. Take time, where you can, for yourselves and those closest to you; your mental wellbeing impacts everything in your life. It impacts your family and relationships. It affects your professional life and job performance, not to mention the huge influence it has on your overall physical health. I am fortunate enough to be Chair of an organisation that has such amazing people as its members and I know in these difficult times you will continue to excel as you always do.

I really hope you are able to find time to read this edition of Inspire amongst all of the other demands on your time. I remain proud to be your Chair and continue to be amazed by all that you achieve.

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*Data on File

Matt Rutter

Alan Moore

Prof. Brendan Cooper

ON THE BLOWER

This edition of 'On the blower' is focused on what was revealed at the conference. For more information click on the company name or logo for access to their website.

WELL DONE TO ALL THE MANUFACTURERS

MR

Manufacturers special mentions

Steven Adair
Holly Foster
Nick Chapman
Oliver France
Shireen Elsworth
Phil Pace
Julie Cross
Gwilym Davies
Shaun Locock
Sam Partington
Denzel Joubert
Jimmy Strang
Travers Barr
Darren Murray
Chris Simmons

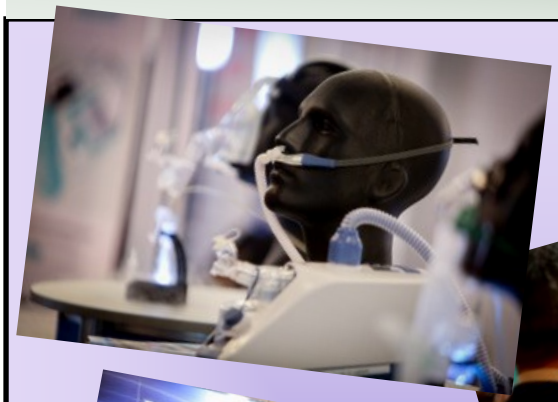
Best conference stand

Vitalograph

Grant Winner

Charlotte Johnson

FROM AROUND THE CONFERENCE...



intermedical

Intermedical have been pleased to assist with research into Bird Fancier's Lung amongst pigeon enthusiasts. At the annual The British Homing World Show of the Year, the EasyOne Pro, Resmon Pro and EasyOn PC were all used to gather data from the attendees. The data was collected with the aim of assisting with research to understand why some develop pneumonitis from exposure to pigeons while some do not. The longer term aim is to develop treatments for this and other forms of ILD. The genetics are being examined as is spirometry and oscillometry data. An abstract was presented at last year's BTS (click here: https://thorax.bmj.com/content/74/Suppl_2/A54.2) suggesting that sub-clinical lung inflammation could be detected by oscillometry/FOT in subjects who were otherwise healthy and had normal spirometry

NSPIRE HEALTH

nSpire Health were very pleased to be exhibiting at another great ARTP conference in Birmingham this year and we were extremely proud to win the ARTP Lung Function Manufacturer of the Year award 2020.

Many thanks to our customers who took the time to respond to the ARTP Manufacturers survey, it was great to win and your recognition of the support we have provided over the last year means so much to us. It was also good to catch up with so many of you at the conference.

Some great news followed the conference, the USA Court approved the exit of our US company from Chapter 11 bankruptcy. Meaning that we are now proceeding full speed ahead with our plans and developments that have been in process since early autumn 2019. The US office has also relocated to a new facility in March and production is back to normal service. The UK office of nSpire Health as you know has been operating as normal throughout the period.

It's now business as usual. We will continue to keep you up to date with our progress and our plans in terms of new software and product releases.

Thank you for your continued support.

ON THE BLOWER

Full Paediatric Mask Range from RemServe Medical

Vented and Non-Vented Options

At RemServe we are continuously attempting to put together a more comfortable, more efficient, and more durable range of masks and we pay extra special attention to the Paediatric ranges as they are often overlooked. We now offer a full range of masks ranging from Neonates all the way into adolescence.

NeoQ Neonatal Nasal

Starting with the NeoQ, the new cushion technology is available in **4 sizes**, starting from **<5 kgs** (Less Than), **4 to 6 kgs**, **6 to 8 kgs** and **>8 kgs** (Greater Than).

The one-piece soft silicone mask allows excellent forehead positioning, support and clinical application, allowing for natural structural development in babies and children.

Cirri Mini – Nasal Mask

Maximum comfort designed for ease of use and application with three sizes covering an age range from 0 – 8 years.

The 360-rotating elbow promotes freedom of movement with medical grade super soft silicone providing an excellent seal.

Cirri Mini – Full Face Mask

The same as the "Cirri Mini – Paediatric Nasal", the Full-Face variant offers the same 360 rotating elbow and covers the same age range of 0 – 8 years.

The Full-Face range comes in 4 sizes from Small up to an Extra-Large fitting with the same soft medical grade silicone being used for the cushion.

FitMax – Total Face Mask

The FitMax Total Face Mask has been specifically designed with Paediatric and infants in mind where a good seal is paramount to the administration of CPAP & NIV treatment.

The mask features slide-in clips for easy positioning and removal of the mask. Included is the soft padded, absorbent double-faced bonnet headgear for added comfort.

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S-MED showed the latest version of our DOMINO Software together with some exciting new features designed to streamline workflow when setting up or analysing recordings. This new version brings together the different versions of DOMINO and DOMINOlight into one version. Domino V3.0 has been completely rewritten from the ground up and is now fully 64-bit compatible and is also certified to run on Windows 10. We will be rolling this out to all customers in the coming months.

Key features include:

- Full support for SOMNOtouch, SOMNOscreen and SOMNO HD hardware for both ambulatory and on-line recordings
- New Custom Report Designer with Export to MS Word .DOCX format
- Full support for our Home Sleep Camera for ambulatory recordings with synchronised Video. It is now also possible to fully edit video recorded on the HSC
- Anonymisation of recording folders to comply with GDPR regulations

As always, software updates continue to be free of charge!

We also showed our new extended range of low-cost disposable accessories available for all sleep equipment and now have available:

- Disposable RIP Effort belts for all ages
- Disposable Standard (non-RIP) Effort belts for all ages
- Disposable Nasal and Nasal/Oral Cannula
- Disposable SpO2 probes
- Disposable ECG, EEG and EMG Electrodes

S-Med continues to maintain its strong reputation in the sleep diagnostic market as the supplier of the SOMNOmedics range of Sleep Diagnostic Equipment. The success of SOMNOmedics continues and we showed the exciting SOMNOtouch Respiratory Screener, weighing in only at 58g with its large colour touch screen display and built-in SpO2 monitor and rechargeable Li-Ion battery.

We wish to thank the ARTP membership for your continued support and we look forward to continuing working with you to achieve your goals.

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ON THE BLOWER

Vitalograph®

A Global Leader in Respiratory Diagnostics

Thank you to all attendees who took the time to visit the Vitalograph stand and talk to us.

The ARTP annual conference is one we look forward to each year and Birmingham 2020 was a fantastic opportunity to speak to customers and showcase our product range. Our stand featured a reaction time competition and interactive demonstrations of our devices. Delegates voted it best at the event for the third year in a row. We truly appreciate the recognition.

Adrian Fineberg, Executive Vice President UK & Ireland Healthcare Sales & Service commented **"I always enjoy the ARTP conference, meeting old friends and new. It's been a busy few years at Vitalograph as we work towards a comprehensive range of respiratory diagnostic products that fully meet the needs of modern respiratory services. It's exciting to be finally able to share this with customers."**

Our **NEW BODY PLETHYSMOGRAPHY PFT** system and our **PORTABLE PFT** system were stars of the show this year. Both are designed with connectivity in mind via Morgan Scientific's ComPAS2 software. For the first time we were able to show what a future pulmonary function service looks like using a full range of products from Vitalograph: from PC-based, Handheld and Desktop Spirometers, through to Portable and Lab based PFT systems running on a single software platform with EMR interface.

The feedback from our two busy workshops was excellent. We presented an in-depth look at our future development plans and also ran a practical session on using the Hans Rudolph simulator as part of quality assurance procedures.

This year, our newest team members, Sanita Nijjar and Alex Fitzpatrick attended the conference. They can be contacted at sanita.nijjar@vitalograph.co.uk (UK Central) and alex.fitzpatrick@vitalograph.co.uk (UK South) For all other enquiries please call us on 01280 827110 or email us at sales@vitalograph.co.uk

Team Awards Dinner: Andy Roebuck, Adrian Fineberg, Sanita Nijjaar, Jimmy Strang, Alex Fitzpatrick.

Vitalograph Prize Winner:
Mustapha Camara, Senior Clinical Physiologist at Wythenshawe Hospital

Adrian Fineberg, Jimmy Strang, Patrick Morgan, Sanita Nijjaar, Andy Roebuck, Alex Fitzpatrick.

Thank you ARTP for a holding a fantastic conference and thank you to all the delegates who visited our stand. Congratulations to all those who received their certificates on the evening, a perfect way to be awarded and recognised for their hard work.

We are extremely proud to have the following team members recognised by our customers for their hard work: Kenny Simpson, Darren Murray, Sam Partington, Shaun Locock and Travers Barr.

It was the perfect platform to showcase our Vyntus™ ONE and Vyntus™ BODY supplement with the new bench option which was extremely well received. The stand also had customers perform live tests to allow true patient experience.

For those of you who missed Herman Groepenhoff's popular workshop discussing the differences between the 2005 and the 2017 ATS/ERS standards on single-breath diffusion (TLCO), key changes Herman discussed:

- Volume accuracy change to ±2.5% or ±75ml
- Changes in the DLCO acceptability quality and repeatability criteria
- Quality grading DLCO and reporting best values by grades
- Display a graph of exhaled gas concentration versus volume
- New equations for barometric pressure correction on measured DLCO
- Recommendations for reporting of the DLCO parameters and graphics

Continuing our commitment to support our customers with our education programme we have added further dates to the calendar for customers to be in a small group and have the time to not only increase their knowledge but share experiences with peers. This is held at our newly developed Customer Experience Centre at Vyaire Headquarters in Basingstoke, UK.

Please contact your dedicated account manager for these course titles and dates. It will be on a first come, first serve basis uk-respiratory-sales@vyaire.com

ON THE BLOWER

The following companies were also present at the conference. Click on their logo for more information about their products.

Aerogen	Aerogen® Pioneering Aerosol Drug Delivery
Artiq	ARTIQ
Baywater Health Care	baywater HEALTHCARE
Circassia	CIRCASSIA
Dolby Vivisol	Dolby VIVISOL® Home Respiratory Care
Drive DeVilbiiss Healthcare	drive | DeVilbiss HEALTHCARE
Fisher & Paykel	Fisher & Paykel HEALTHCARE
GVS Filter Technology	GVS FILTER TECHNOLOGY
Intersurgical	INTERSURGICAL COMPLETE RESPIRATORY SYSTEMS — Quality, innovation and choice in respiratory care
LÖwenstein	LÖWENSTEIN medical united kingdom
Medical Graphics and Medisoft	MGC DIAGNOSTICS / medisoft CARDIO-RESPIRATORY INSTRUMENTATION

The following companies were also present at the conference. Click on their logo for more information about their products.

Numed Healthcare	
PARI Medical Ltd	
Philips Respironics	
Radiometer	
ResMed	
Schiller	
Sentec	
SomnoMed	
Stowood	
Vapotherm	

CLEAN MACHINE?

ALAN MOORE

Well, there have certainly been enough songs written about clean machines over the years from greats like Sir Paul McCartney in 1999 to lesser knowns such as 'The Presidents of the United States of America' in 2014, but we'll park that thread for now.

The public often use words like cleaning and sanitisation interchangeably. What is the difference between cleaning and sanitisation? What is often overlooked is that in infection control speak, the differences are quite large. Knowing the difference between these terms can, in some circumstances, mean the difference between life and death. Cleaning is the removal of all foreign material from objects by using water and detergents, soaps, enzymes and the mechanical action of washing or scrubbing the object. ***Sanitisation cannot be accomplished if detritus removal is inadequate; i.e. cleaning has to take place thoroughly beforehand.*** When you sanitise, you are killing/reducing the number of bacteria present by 99.9%, but doing nothing about viruses and fungi. Sanitisation is usually a term associated with a process of wiping down hard surfaces.

So where are we going with this article? Some time ago, both Manufacturers Liaison Group (MLC) and the clinical side of the Sleep Apnoea Consortium (SAC) were asked to provide guidance on the ever-flourishing consumer market in devices claiming to clean/ sanitise CPAP masks, tubing, headgear and humidifiers. From the MLC side, there was some concern expressed that the use of consumer devices was contrary to manufacturer cleaning instructions and that, should damage occur, limited warranty could be invalidated. From the SAC side, input from patient representatives was more in the way of "What is the evidence that such devices are of benefit, and do they work?".

A quick web search found devices from the following companies - SoClean, RisingMed, VirtuOx, Funwill, Idunmed, Carejoy, Sani Bot, and Enshey; there are bound to be more jumping on the bandwagon. The claimed techniques used to "sanitise" involve the application of "Active Oxygen", also known as Ozone, Ultra-Violet light or, a combination of the two. In the same way that ozone is formed naturally by the discharge of electricity during a thunderstorm, quantities of ozone can be produced in a modern electrical ozone generator. This method of ozone generation is formed by corona discharge. A high voltage is passed across a gas stream containing oxygen. The energy of the high voltage splits an oxygen molecule, 0_2, into two oxygen atoms, 0, which recombine with ordinary molecules of oxygen to form ozone, 0_3. Ozone can also be formed in the proximity of certain types of ultra-violet lamps. However, this will only produce O_3 at low concentrations. It goes without saying that if only 21% O_2 is available, as in these devices, then the amount of O_3 that can be produced is substantially less than if 100% O_2 is used as the gas source.

Is there any evidence that the devices actually work and achieve at least 99.9% reduction in bacteria? The only results that could be found were for the SoClean device range. This is to be found in a laboratory test report made available by the company. The results show a reduction of the number of bacteria present by at least 99.9% after a standard 'sanitizing' cycle. The range of cost of these devices is from £29.99 to £249; a very wide range. The take home message when such a range of cost is seen is usually that you get what you pay for to the greater extent.

The Biocidal Products Regulations (EU) 528/2012 (BPR) came into force on 1 September 2013, and, from this date, Ozone has been regulated as an "active substance" under the BPR. Anyone who wishes to market an ozone generator for a Biocidal application within the EU must have their product authorised in accordance with

the BPR. This process has required an "active substance" dossier in respect of ozone to be submitted prior to September 2016 and thereafter a specific application for each product to be marketed within the EU to be submitted from September 2017 onwards. None of the brands identified and currently offered for sale give any indication that compliance with these regulations has been achieved and no evidence could be found of the same on independent search.

It is widely documented that Ozone causes embrittlement (loss of ductility leading to hardening and cracking) of elastomers[1,2]. This is what manufacturers of CPAP devices and accessories are concerned about. They take the cleaning of their products very seriously and have conducted thorough testing to ensure that their claims are validated resulting in limited warranties (not unconditional) for their products. Resmed in their product warranty information specifically exclude "*any damage caused by exposure to ozone, activated oxygen or other gases*". On 31st January 2020, Resmed UK Ltd released the following statement to their UK customers:

"Dear Valued Partner,

We are writing to let you know that over the last several months it has become clear to us that the frequent and prolonged use of ozone cleaning devices is causing damage to some ResMed devices. We have not identified any patient safety risk arising from these issues.

This email is a reminder of our well-established product usage guidelines, and specifically the cleaning methods that are detailed in each products individual user guide.

We are not prohibiting and we are not encouraging, the use of ozone or other aftermarket devices with ResMed products — that decision is up to you and your patients. However, due to the clear effects of ozone on ResMed devices, effective February 1, 2020, damage to ResMed products caused by exposure to ozone will be specifically excluded from our limited warranty.

*We are **not** voiding the limited warranty. Instead, if a ResMed product is purchased on or after February 1, 2020 and is used with an ozone device, and the ResMed product shows damage consistent with the use of an ozone device, repair of the ResMed product will not be covered under the limited warranty. We are providing you advance notice so that you can independently decide whether to continue to sell or support the use of ozone devices based on what is important to you and your patients. ResMed limited warranty language and user guides will be updated to reflect this information and will be available on our website post February 1, 2020. For ResMed products purchased prior to February 1, 2020 and still within their limited warranty period, ResMed will honour refurbishment or replacement for these products (including in the event of damage caused by use with an Ozone device) with standard return procedures and policies.*

Additionally, we have developed sample text for you to communicate with your patients on this issue that is available for download here.

We appreciate you choosing ResMed therapy solutions. If you have any questions or concerns regarding this communication, please contact ResMed Customer Service on 01235 862997

Sincerely,

Resmed Care Team"

We now have a very clear position statement and that is to be welcomed. It would be very helpful to the public if all the CPAP manufacturers issued similar statements so that there is absolutely no confusion.

Is there any evidence to back up the manufacturers' stance that cleaning without the use of a sanitising device is indeed perfectly adequate?

Chin et al[3] in 2013 investigated the association of CPAP bacterial colonisation with Chronic Rhinosinusitis (CRS) and concluded that "*having a positive culture in the CPAP reservoir does not seem to lead to an increased symptomatology of CRS: although the reservoirs often become colonised, there seems to be no clinical impact*".

Mercieca et al[4] in 2017 investigated whether CPAP was a route for infection in those with Obstructive Sleep Apnoea. They concluded that "*the use of CPAP, choice of mask and humidifier have no significant impact on the prevalence of infections and micro-organisms isolated. This is very reassuring to the physician prescribing CPAP therapy and users*."

So, there is no evidence that ordinary cleaning according to manufacturers' instructions poses an increased risk of infection to patients.

ARTP SAC has added the following paragraph to Section 2.4 Cleaning/Infection Control of the ARTP Standards of Care - CPAP Devices (Technical and Performance) document, version 5.0:

"*Recently, consumer devices, which are readily available, purporting to 'eliminate 99.9% of CPAP bacteria, germs and other pathogens safely and naturally with no water or messy chemicals needed', and also claiming 'compatibility with major CPAP models' have come into being. The use of such devices is not recommended by any of the major CPAP device manufacturers. Using such devices may invalidate warranties for CPAP Devices, CPAP masks, headgear and tubing accessories. A review of the available literature yields no evidence that the risk of infection from the use of traditional cleaning methods, as recommended by manufacturers, is significant.".*

As ever, I like to give a little history lesson. It's a bit of a lengthy one so some may wish to skip it; that is your prerogative, but you will miss the conclusions. This is a true account from my lifetime which most of you are far too young to have experienced and many may not even know about. It portrays a classical example as to what can go wrong if manufacturers instructions are not followed precisely and/or there has been a lack of investigation as to how seemingly harmless substances behave in atypical conditions.

On Jan. 27, 1967, the interior of NASA's AS-204 command module (CM), occupied by American astronauts Roger Chaffee, Virgil "Gus" Grissom, and Ed White, caught fire during a rehearsal of its scheduled February 21 launch. By the time the ground crew was able to open the hatch, the three astronauts had perished. It took just 26 seconds from first alert to the deaths of the astronauts. If there is any 'saving grace' in this account, it is that the astronauts died from carbon monoxide poisoning rather than fire. The first item of their protective equipment that melted was the plastic hoses carrying the oxygen supply to their space suits. The test session was subsequently given the mission name Apollo 1[5].

To meet President Kennedy's challenge of landing a man on the Moon before 1970, NASA had to develop an unprecedented amount of flight hardware, training protocols, and mission procedures in just a few short years. In this high-stakes, high-risk atmosphere, the U.S. space industry developed what is commonly referred to today as "go fever" — a phenomenon in which people push themselves, despite great danger, to meet a previously chosen goal.

Unfortunately, "go fever" was causing concern for the primary and backup crews of Apollo 1. For example, during a spacecraft review meeting held on August 19, 1966, the astronauts expressed worry about having so much flammable VELCRO® inside the cabin.

Instead of 0.32 m^2 of VELCRO®, the permitted maximum, there were 3.2 m^2 on board that morning along with two mats made of synthetic fibres. Despite these concerns, engineers kept the flammable material in the capsule to facilitate the securing of tools and equipment and the Feb 21st launch continued as planned. Cape Kennedy Air Force Station Launch Complex 34A was the site for the "Plugs Out Integrated Test" of the AS-204 spacecraft on Jan. 27, 1967. "Plugs Out" described a test of the vehicle to see how it performed under internal power, with no umbilicals supplying off-board power to the ship. The rehearsal was dubbed "non-hazardous" since no pyrotechnic systems were armed nor was the rocket fuelled. At 1:00 p.m., the crew climbed into the capsule and were strapped into their seats. Grissom immediately reported a foul odour of "sour buttermilk" circulating through his suit. The simulated countdown was suspended at 1:20 p.m. and resumed at 2:42 p.m. when engineers could not identify a cause of the odour. At this point, the complicated three-layered hatch was closed. Even under the best of conditions, opening the hatch was known to take a minimum of 90 seconds.

The air in the cockpit was then replaced by pure oxygen, pressurized to 16.7 psi, to drive out any air that entered the cockpit as the crew boarded as well as to seal the plug door. Such a door seals itself by taking advantage of a pressure difference established across its two sides. As the cabin is pressurised, a wedge-shaped door is forced into a socket, forming a seal that prevents it from being opened until the cabin pressure can be released. Most commercial aircraft in service today use a plug door design. The system design was such that, once the capsule was in space during an actual flight, the 100% oxygen atmosphere would have been lowered to 5 psi to reduce the risk of fire while still sealing the hatch against the almost zero pressure of space.

At exactly 6:30:55 p.m., engineers detected a power surge that accompanied an electrical short, probably sparked by a chafed wire, somewhere in the lower left side of the Command Module near the environmental control unit below Grissom's seat. The Apollo 1 fire now had its ignition source. The initial source of fuel for the fire was the polyethylene tubing that covered the wires running throughout the capsule. Several large patches of adhesive VELCRO® hooks that were attached to the wall panels of the Command Module, leg-rests, and seats were the next materials to explosively ignite. The fire and disaster followed. At 6:31:19 p.m., the interior pressure reached 29 psi and burst the inner wall of the Command Module, allowing ambient air into the cabin. All transmissions of voice and data from the spacecraft terminated by 6:31:22. The time period that had elapsed since the power surge was just 26 seconds.

What had happened as a result of inadequate testing was that the pressurised 100% oxygen environment dramatically changed the flammability of the interior fabrics and was critical to the rapid spread of the fire inside the capsule. In fact, literature indicates that polyethylene and VELCRO® burn over twice as fast in oxygen at a pressure of 16.5 psi than at 5 psi. Therefore, the primary fuels for the fire burned more than twice as fast as they did under the conditions for which they were evaluated. Transcripts from a Senate hearing[6] indicate that the polyethylene and VELCRO® inside Apollo 1 may have even burned at a rate of 6.5 cm/s, which would have consumed a ship the size of an Apollo Command Module in under a minute. In short, the pressurised oxygen atmosphere made almost every material inside the cabin, even materials not normally considered highly flammable, burst into flames when given a spark. Following on from this disaster, 100% oxygen environment was reduced to 34% for subsequent missions. The door design meant that it was impossible for the astronauts to open it.

Earlier, I quoted the definition of “go fever” as “a phenomenon in which people push themselves, despite great danger, to meet a previously chosen goal”. In the consumer devices world, I would define “go fever” as “pursuing the creation, marketing and sale of a device without due diligence, with profit being the primary driver”. Due diligence is legitimately defined as the care that a reasonable person exercises to avoid harm to other persons or their property.

Please be reassured that there is no suggestion of a linkage between the Apollo 1 scenario and CPAP sanitising devices; there is no evidence of ozone generators bursting into flames that we are aware of. The similarity is that due diligence is not evident in either case. Other consumer examples in recent times with far more serious consequences are:

- Washing machines, tumble driers, dishwashers, refrigerators and freezers which turn into incendiary devices.
- High-rise building external cladding.

To conclude:

a) Always follow the manufacturers' instructions whether in relation to cleaning or anything else.

b) In the case of cleaning for CPAP devices and their accessories, the evidence shows that nothing else is necessary.

c) Reinforce the following of manufacturers' cleaning instructions to your patients.

d) Research and Development can and does kill if not subject to rigorous control.

e) Ensure you always keep your fire exits clear.

f) Be careful where and how you use Velcro. If you do use it, using the non-flammable version is highly recommended.

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The impact of change from European Coal and Steel (1993) reference range to Global Lung Initiative set on diagnosis for Spirometry and single-breath carbon monoxide test

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Introduction

The European Coal and Steel (ECCS) 1993 reference set for Spirometry variables is commonly used in Europe, however many major bodies such as the Association Respiratory Technology and Physiology (ARTP) are recommending that laboratories shift to the Global Lung Initiative (GLI) 2012 reference range.

The cohort of people used in the ECCS were male coal miners between the ages of 23-65 years old, therefore female data is estimated[1]. Major changes have occurred in anthropometric data since the cross-sectional study was performed in the 1960s. Average population body height, weight and life expectancy have all increased, and as all three factors are significant determinants of "normal" lung function, normal ranges may have likely shifted[2]. Ethnic origin can also affect pulmonary function due to the varying anthropometric data between different ethnic backgrounds. For example, African-Americans generally have a forced expiratory volume in 1 second (FEV_1) and vital capacity (VC) of 14% less than Caucasians, due to the difference in thoracic sizes at a given stature[3]. The ECCS study cohort mainly consisted of Caucasians, other ethnicities were omitted from the equations that mapped the reference set. Therefore, ECCS is unsuitable for contemporary best practice with varied ethnicities.

Several alternative reference sets have since been published; each with its own improvements and limitations. GLI reference sets were born out of this.

Accurate predicted values are critical to aiding correct diagnosis of respiratory conditions and pre-operative risk assessment. This project used data collected at the Lung Function Laboratory, Wythenshawe Hospital, January-December 2018. Differences in the proportions of patients with aberrant lung function with ECCS and GLI reference sets were compared, and the resulting change in patterns of ventilatory defects due to a shift from ECCS to GLI ranges were noted.

Although studies comparing both reference ranges have been published, the effect of implementing GLI equations has not been reported for patients referred for investigation at Wythenshawe Hospital. Anthropometric and demographic background in The North West may be different from areas in which the other studies have been completed. It is important to stress that underlying disease prevalence in the North West area has not changed but using different reference sets can help identify a disease that was previously not recognised and/or improve estimation of its severity.

Patients and Methods

The purpose of this study was to compare the difference in diagnostic categories between GLI 2012 and ECCS for spirometry and GLI 2017 and Wythenshawe Equations for single breath carbon monoxide uptake (TL_{CO}). 7868 males and 6255 females, aged 14 to 97 years, who attended the Lung Function Laboratory between 2017/2018 were included. The data was collected using CareFusion VMAX software and hardware (Yorba Linda, CA USA): spirometry and TL_{CO} data for 8579 and 5544 patients respectively. Recorded measurements were stripped of patient identifiers and exported to a Microsoft Excel spreadsheet.

The regression equations for both reference sets (ECCS/Wythenshawe & GLI) were then applied to the anthropomorphic data and reference values calculated. The measured data was then expressed as a standard residual (SR) by comparing the recorded value to the calculated mean and the difference expressed in multiples of SRs. An SR score greater than -1.64 confirms there is only a 5% chance of the individual with this lung function being “normal” compared to the reference population. Thus this test result sits below the lower 5th percentile or LLN of a healthy population[4].

Data analysis was done using SPSS version 27 (Portsmouth, UK). Outcome measures were:

1. Number of patients classified as abnormal when using GLI compared to ECCS
2. Number of patients where the observed defect had changed and in what direction – normal when previously below LLN or now below LLN when previously normal.
3. Number of patients with abnormal spirometry using GLI reference that had the severity of their disease altered using the NICE 20185 criteria (where %predicted decided threshold points).

Results

A restrictive ventilatory defect increased in prevalence when using GLI: 33% of referrals compared to 19%

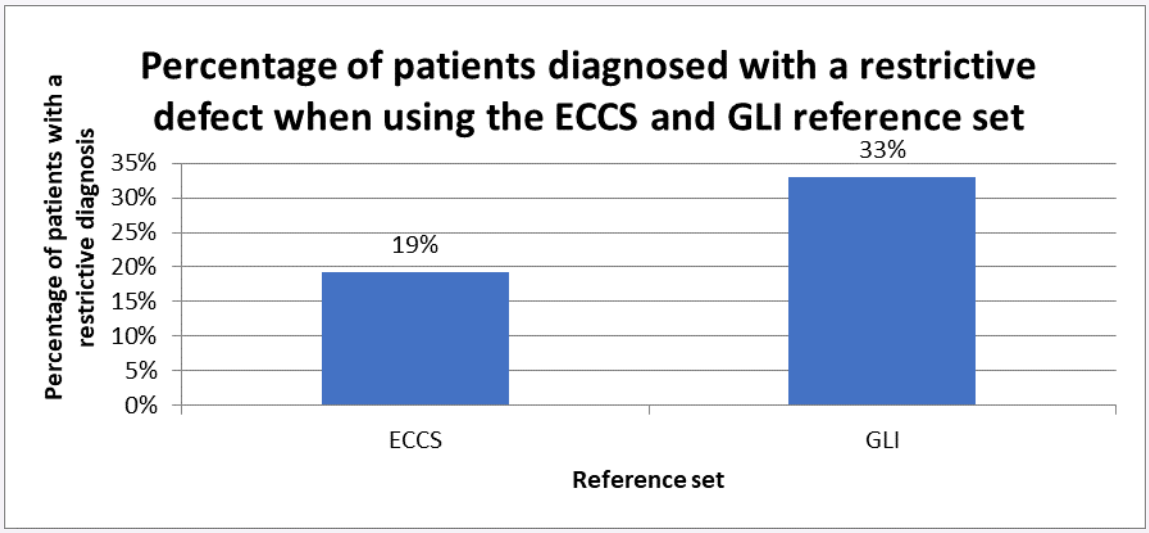

Figure 1: A restrictive diagnosis when using the ECCS and GLI reference set on a patient sample of 8579.

when using ECCS (Figure 1) amounting to a 41% increase.

25% vs 18% of patients had airflow obstruction according to ECCS vs GLI (Figure 2). All patients classified as obstructive under GLI also had an obstructive ventilatory defect under the ECCS reference set.

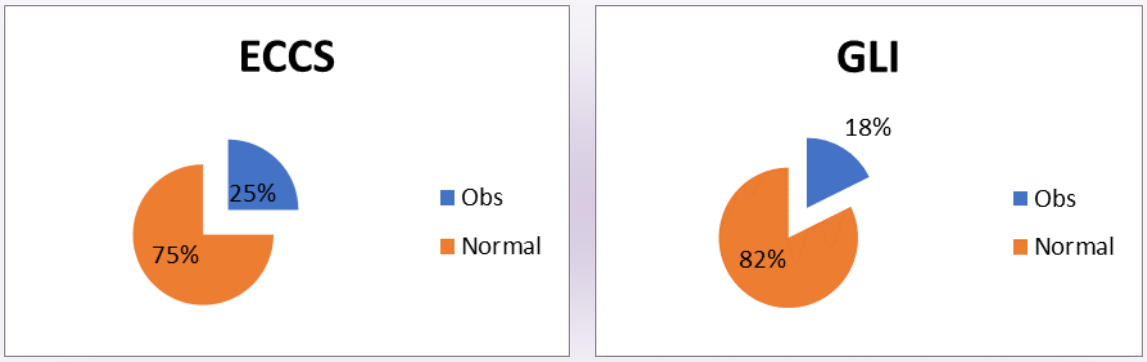

Figure 2: The difference between an obstructive or normal diagnosis when using both reference sets.

However, 628 (7%) patients classified as obstructive with ECCS were normal using GLI (Obstruction defined as a FER<LLN).

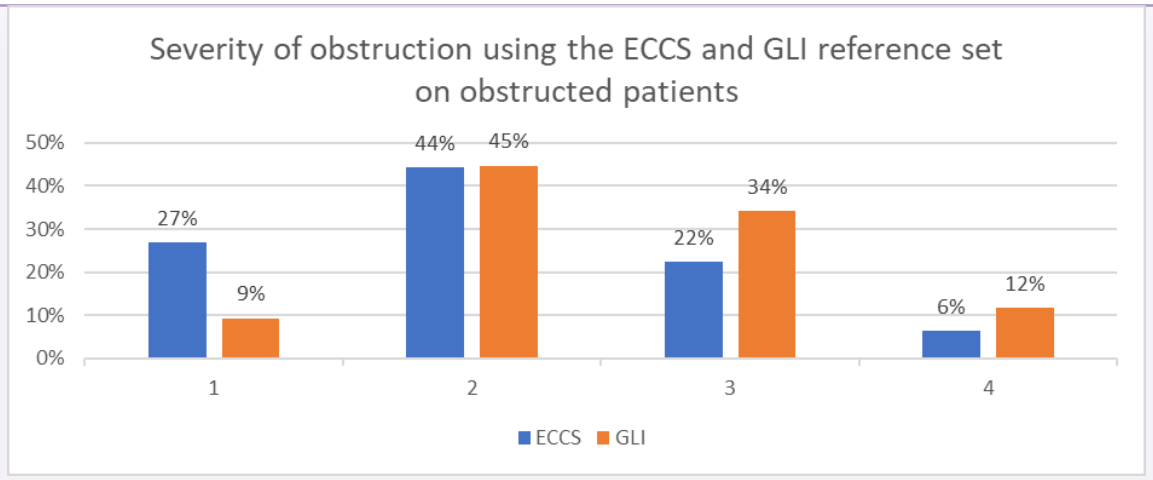

Figure 3: Obstruction severity when using the ECCS and GLI reference sets.

Figure 3 demonstrates distribution of airflow obstruction severity using NICE 2018. When obstruction is present, GLI is more likely to yield a greater severity of obstruction.

		GLI		Total
		Normal	Abnormal	
Wythenshawe Standard	Normal	1743	2248	3991
	Abnormal	3	1550	1553
Total		1746	3798	5544

Table 1: Agreements between GLI and ECCS on normal and abnormal TL_{CO} readings.

Figure 4: The difference in a normal or abnormal diagnosis on TL_{CO} when using both reference ranges.

Table 1 and figure 4 demonstrate levels of agreements on diagnosis using the Wythenshawe generated TL_{CO} equations compared to the GLI 2017 TL_{CO} reference. GLI is more likely to generate abnormal TL_{CO} readings than ECCS.

Discussion

The diagnosis and severity of a ventilatory defect differed in a significant percentage of patients when the two reference sets were applied in this study. This is unsurprising given they derived the predicted values from different subject pools.

One can have greater confidence in the accuracy and specificity of GLI outcomes for several reasons. Available technology at any one time dictates equipment design and performance. For example, Crapo and Jensen (2003)[8] compared the accuracy of spirometers in 1987 and 2001; the measurement of different flow rates varied considerably more in 1987 than in 2001 (Figure 5). Not only were much larger number of subjects included in the GLI study compared to ECCS, but all subjects were screened for underlying disease and were tested on equipment meeting the latest test standards[6]. Data collected for

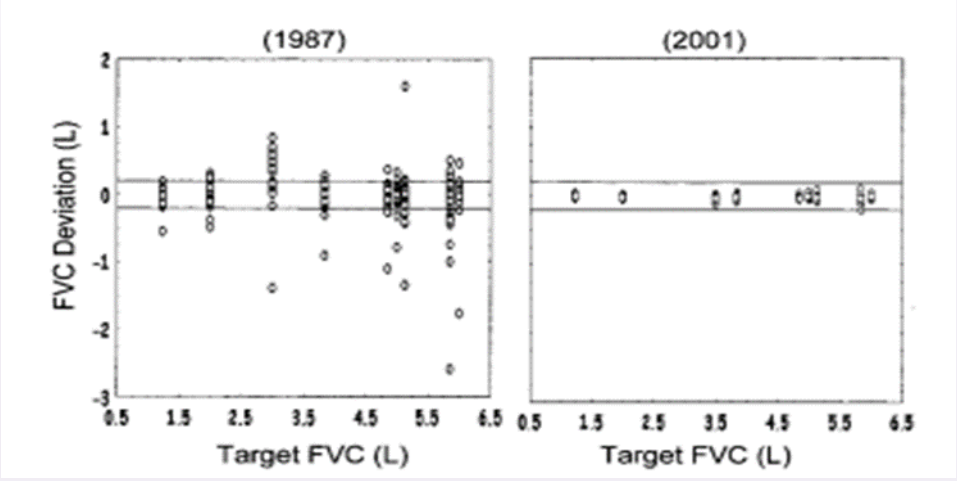

Figure 5: Spirometers accuracy in the years 1987 and 2001[8].

GLI consequently met current testing guidelines. In comparison, there were no recognised spirometry guidelines when ECCS commenced[7] and the equipment used in ECCS is not comparable to the current technology today.

The GLI uses one equation which helps to compare results from childhood to adulthood with a dynamic standard residual corrected for actual age, height and ethnicity. The GLI equation [log(Y) = a + b•log (height) + c•log(age) + d•Ethn + spline + error] uses a logarithmic scale and the values of a, b and c in the equation are calculated using the linear coefficients[6] driven by the specific patient's ethnicity, age & height. Therefore this single equation gives a dynamic upper and lower limit of normal depending on the patient's age, height and ethnicity. In contrast, ECCS consists of simpler multiple linear regression equations with a fixed SR yielding a uniform upper and lower limit of normal for an individual at a specific age and height[6].

Additionally, comparing lung function in paediatrics vs adults is challenging[9]. ECCS treats childhood and adulthood as two separate populations making direct comparison more difficult[6]. As the GLI uses one equation it is possible to get predicted values from anyone above the age of 3 years old, whereas ECCS is unable to do this. Therefore, with ECCS a clinician needs to use a different reference set [Zapletal (1987)[10] to obtain data for a patient below 18 years and there is no guarantee that this would align with ECCS. If paediatric and adult references do not align, this could result in a patient having a large predicted value difference on their 18th birthday[6].

Another limitation of ECCS is the fact the cohort were male coal miners aged 23-65 years old: female reference ranges were reduced by 20% and are therefore an estimate[2]. Beyond 65 years, ECCS equations are extrapolated to produce estimates and it is difficult to predict the accuracy of the results. Middle aged individuals may experience a greater lung function decline than someone over the age of 80, therefore it's not scientifically robust to equate lung function decline between different cohorts of people. The GLI spirometry data were derived from people aged 3-95 years which circumvents this problem.

Similarly GLI TLCO references were based on subjects 4-80 years old, which is more inclusive than the Wythenshawe equation cohort[6]. Lung function varies between different ethnicities: the cohort used in the Wythenshawe Eqn. mainly consisted of Caucasians and lung function was estimated using a fixed empirical correction for other ethnicities6. GLI included range of ethnicities and therefore the predicted values are not estimated but specifically calculated.

The anthropometric data has dramatically changed since the 1960's. The average age of puberty when growth spurts and hormonally driven changes in thoracic size occur, has also been declining and therefore it is difficult to compare predicted values between different cohorts[11]. As countries develop, with improved nutrition and healthcare, this leads to increased average height at any given age, which can

have a profound effect on lung function[12]. These trends have shifted normal lung function ranges therefore making historical ECCS predicted values no longer applicable.

A combination of the above results in the reference sets yielding different predicted values. Figure 6 compares predicted FVC values and lower limit of normal (LLN) for males at a range of ages using both

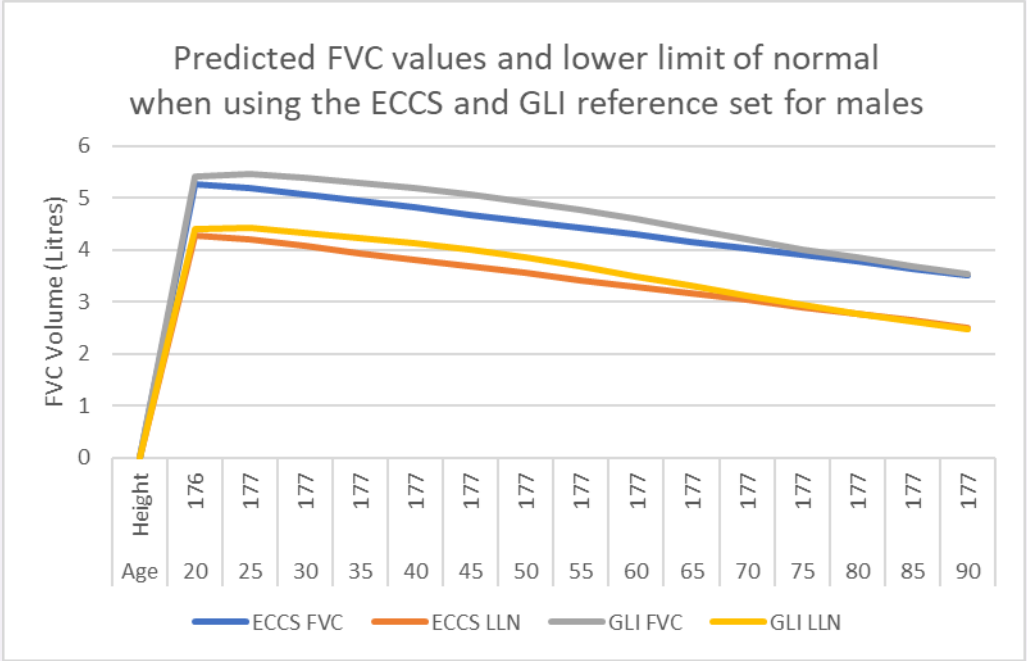

Figure 6: The difference in predicted FVC values when using the ECCS and GLI reference sets on males

reference sets. Both reference sets agree that lung function peaks at roughly similar ages. The predicted value and the lower limit of normal are larger for GLI than ECCS reference set. This has consequently resulted in numerous people being classified as normal using ECCS but restrictive when applying GLI.

For a 62-year-old 187 cm tall Caucasian male, ECCS lower limit of normal FEV_1/FVC % ratio is 66.3% vs GLI is at 64%. Hence with GLI's lower limit of normal being lower, patients are less likely to be labelled obstructed.

It's important to note that we are not reporting an increase in prevalence of abnormal ventilation or deranged TL_{CO}. These have been present the whole time but, in some cases, it remained undetected due to the inappropriate predicted values used. GLI is the best reference set currently available; however it still has areas of improvement for example, ethnicities such as Japan & Polynesia were minimally represented[13].

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A brief guide to the various strengths and limitations of the available Hypoxic Challenge Test methods

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Introduction

The maximum permissible cabin altitude of a commercial airliner is 8,000 feet. At this altitude, the partial pressure of oxygen (O_2) is equivalent to that at sea level when the fraction of inspired O_2 (FiO_2) is reduced to ~ 15%. This hypoxic environment is unnoticeable by healthy travellers but it can pose a challenge for patients suffering with significant respiratory disease. As such, the Hypoxic Challenge Test (HCT) is used to assess whether a patient may require supplemental O_2 during air travel. Compared to most simple and complex lung function tests, there is little guidance on how to perform a HCT. The British Thoracic Society (BTS) has produced several excellent publications providing recommendations on the management of patients during air travel[1,2] but they only discuss the clinical usefulness of a HCT and not the methodological intricacies of the various techniques.

It is therefore the aim of this brief article to provide an overview of the different methods for performing HCTs and present their key strengths and weaknesses.

Hypobaric chamber

In contrast to all other HCT methods which manipulate the FiO_2 of the supplied gas, only a hypobaric chamber exposes individuals to hypoxia by simulating the reduced barometric pressure of airplane cabins. For the majority of patients, breathing a FiO_2 of 15% will induce a comparable decline in the partial pressure of arterial O_2 (PaO_2) to that occurring during the reduced barometric pressure at 8,000 feet[3]. However, at 8000 feet, gas in non-ventilated regions of the lungs (e.g. bullous lung disease) will expand by ~ 38% according to Boyle's law[4]. This expansion can significantly impair ventilation of communicating regions of the lungs further reducing a patient's PaO_2. This would not be replicated by inspiring 15% FiO_2 at normobaric pressure.

Although a hypobaric chamber would provide the most accurate conditions for simulating altitude, they are not available for routine use in a healthcare setting for several reasons. A hypobaric chamber is extremely expensive, requires a large space and highly skilled staff to run the tests and it carries significant health and safety risks.

Normobaric hypoxic chamber (e.g. a body plethysmograph)

An alternative approach to expose patients to hypoxia, equivalent to that experienced during air travel, is to use a normobaric chamber. In this case, the FiO_2 is reduced by addition of nitrogen (N_2). Purpose-built normobaric chambers are commonly found in academic laboratories, but these can be costly and spacious. A simpler solution, utilised by clinical lung function departments, is to adapt an existing body plethysmograph which is already a sealed unit[5]. Certain models of body plethysmographs have small access ports through which N_2 can be entrained to reduce the FiO_2. These access ports are also necessary for passing through cannulae for supplemental O_2, sensors for pulse oximetry and/or transcutaneous CO_2 and importantly for a sampling line connected to an O_2 sensor. Monitoring the FiO_2 and adjusting the entrainment of N_2 is paramount for the safety of the patient but also for the accurate simulation of air travel conditions.

There are numerous benefits to using a normobaric chamber for a HCT. The most significant is that a mouthpiece or facemask is not required which abolishes the discomfort and hyperventilation resulting from wearing these apparatuses. As such, a normobaric chamber offers an excellent option for performing a HCT in paediatrics who may not tolerate a facemask or mouthpiece. In addition, a parent can accompany the child in the chamber and keep them entertained. Assuming the test is performed by experienced staff, this method has the potential to deliver a precise 15% FiO_2. This, as described later, is not always true for methods using mouthpieces and facemasks. Furthermore, rebreathing and pooling of supplemental O_2 (via a nasal cannula) should be negligible inside a sufficiently spacious body plethysmograph (recent, small volume plethysmographs will need testing).

Despite these significant benefits associated with the use of normobaric hypoxic chambers, our recent survey indicated only a very small number of departments in the UK, Australia and New Zealand used this HCT method[6]. This method for delivering a HCT is only a viable option in departments that have a body plethysmograph with an access port already in situ and the capital to purchase an O_2 sensor. Other significant limitations of this method are as follows. Without proper training and careful monitoring, this method can be dangerous due to incorrect titration of N_2. Limited access to the chamber prevents blood gases from being obtained during hypoxic exposures. This method may not be appropriate for patients with significant claustrophobia. The temperature and humidity can rise significantly inside the body plethysmograph.

Venturi mask

In routine clinical care a venturi mask is normally utilised to deliver gas with a raised FiO_2 with good precision. 100% O_2 is driven through a small orifice in the mask and according to Bernoulli principle the pressure lateral to the jet becomes sub-atmospheric. Room air is subsequently entrained into and mixes with the 100% O_2 jet. Specifically, if 10 l/min O_2 is driven through a 40% venturi mask (red valve), 31.4 l/min of room air will be entrained, providing a total flow of 41.4 l/min at a FiO_2 of 40%. Vohra and Klocke (1993)[7] first described how the 100% O_2 can be substituted with 100% N_2 in order to deliver a hypoxic gas mixture that is close but not exactly 15% O_2.

The main benefits of this method are that it is a simple test to perform and that it is financially viable for most departments because it does not require capital investment. All that is required to perform a HCT using this method is some O_2 tubing, a 100% N_2 cylinder with a flow regulator and a 40% venturi mask (red valve). Venturi masks are single patient use so disinfection and re-assembly are not required. A further benefit of this method is that a nasal cannula can easily be worn under the mask to deliver supplemental O_2. Finally, due to the minimal dead space of most models of venturi masks, re-breathing and/or pooling of supplemental O_2 within the mask is trivial. However, there are a number of limitations of using this method to perform a HCT that must be addressed.

Firstly, the assumption that the venturi jet will always provide 15% O_2 is incorrect. In Vohra and Klocke's (1993)[7] seminal paper describing this method it was reported that the O_2 concentration delivered by two different batches of the same model of commercially available venturi mask was significantly different. Indeed, the second batch produced a significantly lower FiO_2 of ~ 14%, which corresponds to an altitude of ~ 10,000 feet. Anecdotal reports of similar findings suggest this is not an isolated event. As such, it would be advisable to use an O_2 sensor to test the O_2 concentration produced by each new brand of venturi masks and also re-assess after any subsequent change in batch number.

The second significant limitation is that even if the venturi valve is correctly manufactured and produces

the desired jet of 15% O_2, the actual FiO_2 inhaled by the patient may still not be 15% O_2[8-12]. If the total flow of the venturi jet is less than the patient's inspiratory flow then extra room air must be drawn into the mask to satisfy the deficit. Venturi masks do not seal well and the large expiratory ports (holes) in some models are located <1 cm from the nares so ideally positioned for entraining room air. As discussed earlier, the total flow of the venturi jet when driven by the recommended 10 l/min O_2 is only 41.4 l/min. However, N_2 is 14% less dense than O_2 and thus less room air will be entrained, so for simplicity let's assume that the total flow is ~ 40 l/min[13]. This only equates to a flow of ~ 0.67 l/sec which can easily be exceeded during normal tidal inspirations at rest.

Several studies have reported the O_2 concentration of venturi jets to be stable when the flow rate of 100% O_2 is increased beyond the recommended 10 l/min[7]. Therefore, a potential solution to the aforementioned limitation of using a venturi mask is to increase the flow of 100% N_2. Theoretically increasing the flow of 100% N_2 to 15 l/min would be expected to provide a total flow through the mask of >60 l/min (1 l/sec). However, please note we are not aware of any published studies to date that have confirmed the stability of the venturi jet using different flow rates of 100% N_2 so we would recommend using an O_2 sensor to test the resulting concentration of O_2 prior to use on patients.

Pre-mixed 15% O_2 gas supply

Mouthpieces

In contrast to the three HCT methods described above whereby the gas composition is produced at the time of undertaking the HCT, the desired gas composition can be delivered using a pre-mixed 15% O_2 cylinder as was first described by Gong et al[4]. In this study, subjects breathed from large Douglas bags that had been pre filled using 15% O_2 cylinders. A mouthpiece and a set of one-way valves prevented any re-breathing and ensured only gas from the Douglas bags could be inhaled. Supplemental O_2 was administered via a port in the inspiratory circuit. A common adaptation to this method is to use a continuous flow of gas directly from a pre-mixed cylinder and include a small volume reservoir bag in the inspiratory circuit to ensure there is sufficient flow to match patients' inspiratory requirements. Another possible adaptation is to attach a demand valve to the inspiratory circuit, which conserves the cylinder life.

Other than a negligible degree of re-breathing due to the limited dead space, using a mouthpiece ensures that the O_2 concentration actually inhaled by the patient is 15%. However, using a mouthpiece has several significant limitations. Mouthpieces can quickly become uncomfortable to some patients. They cause an increase in saliva production and this can interfere with the normal pattern of breathing. Patients cannot easily communicate whilst using the mouthpiece. Introducing supplemental O_2 directly into the inspiratory circuit does not perfectly replicate the use of a nasal cannula during air travel,

especially in mouth breathers. Finally, mouthpieces can cause significant hyperventilation. For these reasons, many laboratories prefer to use a variety of different facemasks instead of a mouthpiece. Several of the popular choices of facemasks along with their key benefits and limitations are described below.

Loose fitting masks (e.g. disposable high flow oxygen masks)

Numerous commercially available masks exist for providing high flow O_2 to acutely ill patients. It is commonly *but incorrectly* understood that these masks will deliver a FiO_2 of 100% when you use a source of 100% O_2 at a flow rate of > 15 l/min. Following this assumption it stands to reason that if you change the gas source from 100% O_2 to 15% O_2 you have a very simple and effective HCT. Like the venturi mask method there is no capital cost, masks are cheap and disposable so no disinfection/re-assembly are required and supplemental O_2 can be provided using a nasal cannula.

However, these masks will commonly provide a FiO_2 significantly below 100% O_2 when being used therapeutically and conversely, above 15% O_2 during a HCT because room air is inadvertently entrained into the mask at sites where the mask seals poorly to the face[14]. Similarly, as described earlier for the venturi mask, inspiratory flow rates during tidal breathing can significantly exceed the flow of 15% O_2 into these masks. The addition of a reservoir bag in the breathing circuit compensates for some of the deficit in flow but it will only attenuate and not completely stop the entrainment of room air.

Tight fitting re-usable masks

An alternative option to loosely fitting disposable masks is to use a tight fitting reusable mask (i.e. CPAP/ NIV/Fireman style mask). These offer a significantly better seal and subsequently greater confidence that the FiO_2 of the delivered gas is 15%. Depending on the mask used, minor adaptations are required which include blocking/replacing the standard two way expiratory ports with a low resistance one-way expiratory valve and insertion of a reservoir bag into the respiratory circuit[15]. Because these masks have a larger dead space versus cheaper disposable masks it is important to have a high flow of 15% O_2 gas through the mask to limit re-breathing. The flow must be increased further if supplemental O_2 is utilised in order to prevent pooling of O_2 in the mask during exhalation[16]. The main limitation for this method is the reported claustrophobia by some patients. The other limitation, which is applicable to all methodologies using pre-mixed 15% O_2 gas supply, is the high ongoing cost of the gas.

Hypoxic gas generator

It is now well understood that living at altitude or sleeping in a hypoxic tent can enhance the performance of endurance athletes. As such, a range of relatively low cost, commercially available hypoxic generators can be purchased for providing a hypoxic tent. Spurling et al. (2011)[17] described how

these hypoxic generators can be utilised for carrying out a HCT.

Although there is the initial cost of purchasing the necessary equipment, the cost is partly offset by not having to purchase and rent 15% O_2 gas cylinders. Therefore, if the frequency of performing a HCT is sufficiently high, they could offer a cost effective HCT service. An important consideration to make before purchasing a hypoxic generator is determining its maximum deliverable flow. As discussed previously, insufficient flow rates can lead to room air being entrained into the mask and subsequently a higher FiO_2.

Conclusion

This brief article describes some of the key strengths and weaknesses of the various methods that can be used to perform a HCT. However, we acknowledge that the information provided here is a simplified description of the different tests due to article length limitations. It is the authors' intention to produce a more comprehensive manuscript with the aim of helping departments critique their entire HCT protocol and where required, to make adaptations to improve standards.

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ARTP
Association for Respiratory Technology & Physiology
Research Committee
CASE 2
AT RISK??


WELCOME
ARTP
GALA DINNER
Oxygen Uptake: V'O2max
ARTP
Birmingham 2020
16th - 17th January
ARTP
Association for
Respiratory Technology
& Physiology
PHILIPS

James Stockley

ARTP Chair of Research and Innovation

Fresh air

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. We aim not only to provide an interesting read but also to incite conversation within the ARTP community that we hope will continue to drive the evolution of physiological practice.

On behalf of the Research and Innovation Committee, we present an article exploring the concepts and methods of volatile organic compound analysis from exhaled breath. It has been written by Liesl Carr, a clinical scientist and part-time PhD student at the University of Leicester, following her fascinating oral presentation at the ARTP2020 Conference.

Liesl Carr

Department Respiratory Science, University of Leicester, Leicester, UK

Additional editing by Dr. J. Stockley

Concept of Volatile Organic Compounds (VOCs) Measurements in Human Exhaled Breath

Background

Chronic obstructive pulmonary disease (COPD) is a complex heterogeneous respiratory disease that remains a major cause of mortality[1]. Indeed, the World Health Organisation (WHO) estimate that by 2030, COPD will be the third leading cause of death worldwide[2]. The complexity of this disease is challenging and may benefit from simple, repeatable near patient biomarkers to aid with diagnosis, treatment and prognosis.

Breathomics is the metabolomics study of exhaled human breath, which contains a wealth of knowledge about the health of individuals and could give us insight as a possible biomarker for COPD. Therefore, Breathomics presents an opportunity to phenotype this heterogeneity in COPD, although how breath volatile organic compounds (VOCs) relate to airway physiology is uncertain. A recent study highlighted that completing a forced expiratory volume manoeuvre (FEV) induced a specific change in VOC concentrations. This includes two endogenous compounds: Isoprene produced in the body from cholesterol biosynthesis and acetone from lipolysis and glycolysis, both of which could provide additional information on physiology of respiration and gas exchange[3].

VOCs are gaseous carbon-based molecules that can be sampled from breath and have been recognised as far back as 400 B.C. when Hippocrates wrote a treatise on how distinctive smells could be related to certain diseases. For example, the sweet smell of acetone is related to diabetes, fishy smells to liver disease, and ammonia to kidney failure[4]. The earliest known study on breath was completed in 1784 by Antoine-Laurent de Lavoisier, who discovered the presence of oxygen and carbon dioxide in the breath of Guinea pigs. The next discovery was in 1897 by Nebelthau who noted acetone on the breath of starved humans. Francis E Anstie isolated ethanol from breath in 1874, which is still used today by the Police for alcohol breath analysis[5]. In 1970 Linus Pauling detected hundreds of VOCs on the breath using a micro-concentrated technique[6].

Many of these compounds can be classed as endogenous, which means that

they are produced by metabolic processes of the body. VOCs are either derived from the respiratory tract or have passed through the lungs from the circulation, making them good candidate biomarkers in the diagnosis and monitoring of pulmonary disease in particular[7]. However, VOCs can also be exogenous meaning that they are from an external source such as environment, diet or drugs that enter the body, or are metabolised and exhaled by the lungs (Figure 1). These external sources can influence VOC profiles, which increases the complexity of VOC analysis and interpretation.

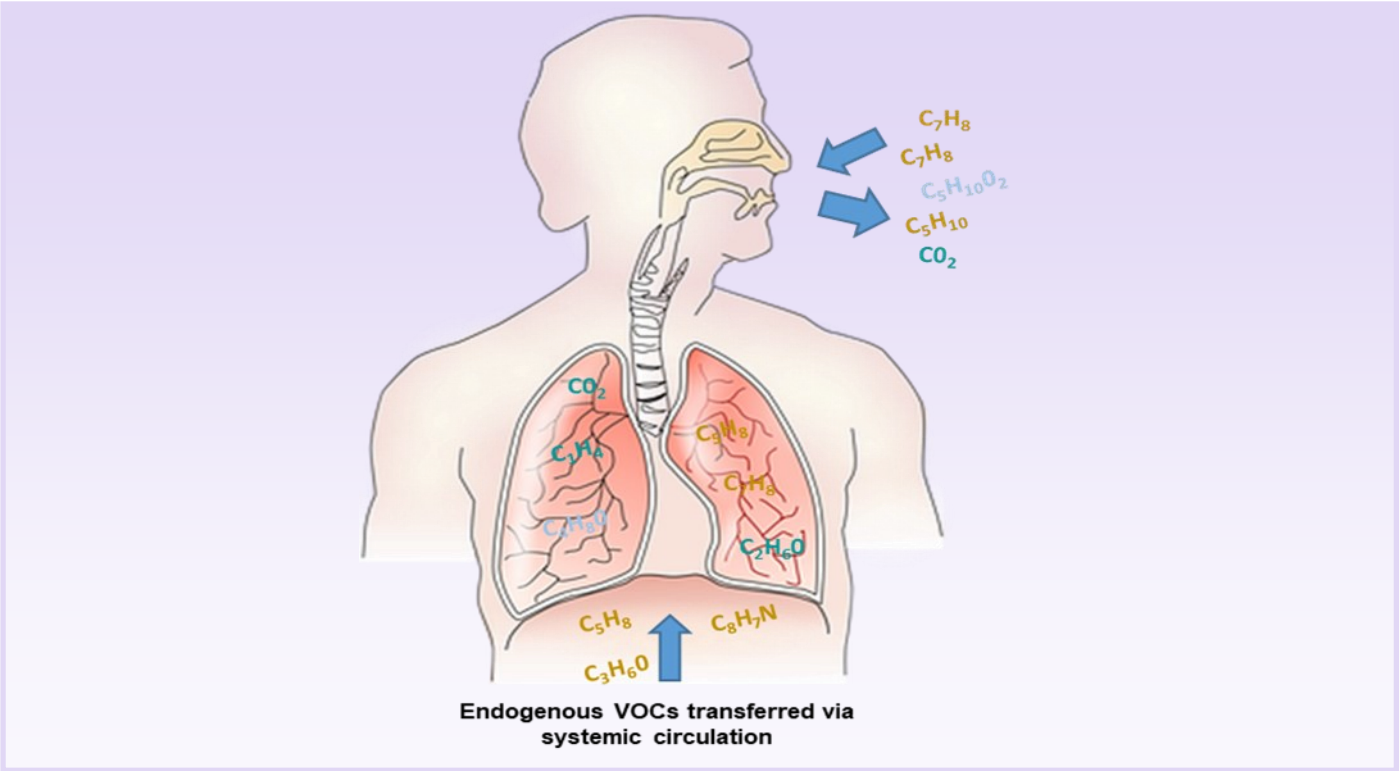

Figure 1: Volatile organic compounds (VOCs) can be endogenous or exogenous in origin. The Figure highlights the different mechanisms and pathways of these VOCs. These may be endogenous (from the pulmonary and systemic compartments) or exogenous (from environmental origins).

With advances in technology, computers and statistical analyses, we are now able to analyse VOCs at trace concentrations as small as parts per trillion by volume (pptv).

Methods

Off-line Method

Gas chromatography mass spectrometry (GC-MS) is an off-line method that is accepted as the gold standard technique for analysis. GC-MS allows for the separation and identification of trace VOCs, which is based on retention time and mass spectra. Advantages of GC-MS include being highly sensitive and reproducible when compared to the Proton Transfer Time of Flight Mass (PTR-TOF-MS), although disadvantages include complex pre-sample processing, prolonged analysis time and the requirement of expert knowledge. Over recent years, a number of studies have been published using GC-MS to examine specific VOCs for possible breath biomarkers in

asthma and lung cancer[8-10]. Breath sample is collected for GC-MS by a face mask but the process is longer than for PTR-TOF-MS. The patient breathes tidally for up to 10 minutes and, during this time, the VOCs are collected at the end of tidal expiration onto a thermal desorption tube (hollow metal tubes that house an absorptive layer). The tubes are then stored in a fridge until collection and analysis is normally completed off-site.

On-line Method

Proton Transfer Time of Flight Mass (PTR-TOF-MS) is an example of an on-line method as it allows real time measurement of VOCs at low concentrations by using hydronium ("protonated" water; H_3O^+). It transfers a positive proton from hydronium to a VOC, providing that the proton affinity of a VOC is greater than that of water. The advantage of using the proton transfer process is that the ionisation is softer than those used in other mass spectrometric techniques and does not lead to excessive fragmentation of the VOCs within breath. Soft ionisation refers to the residual energy on a molecule which can cause fragmentation. However, this method can have a lower sensitivity when compared to other methods and some molecules may not even be detectable. The PTR-TOF-MS can provide a rapid and direct measurement and in the past few years it has been reported in the medical research field and been used in a variety of research studies, including COPD[11]. Background samples are taken prior to the patient testing by collecting sixty seconds of room air. Breath is then collected from the patient using a facemask. During the analysis process the background is removed from the breath sample, yielding a "breath matrix". Figure 2 shows typical breath matrices from a healthy individual and a COPD patient – the x-axis relates to the mass-to-charge ratio of the ionised chemicals and the y-axis is the median value count of the intensities of the VOC per second. The differences between health and disease are often subtle and require subsequent analysis by machine learning software (e.g. linear discriminant analysis).

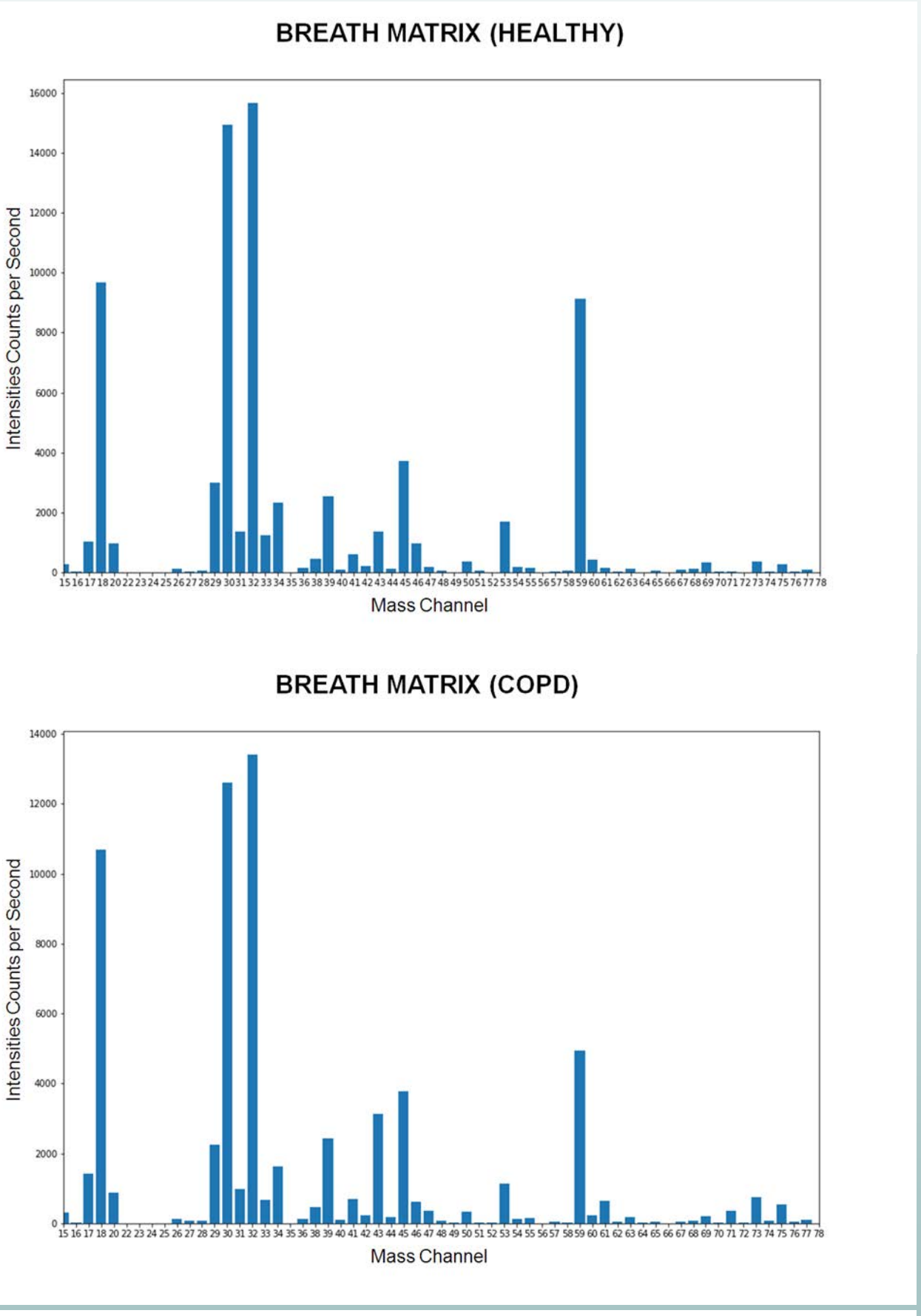

Figure 2: Breath matrices from a healthy individual (top) and a COPD patient (bottom), showing the differential outputs. Note the different scales on the y-axes (16,000 for health vs 14,000 for COPD). Mass channels 15 – 78 each represent the mass-to-charge ratio of different ionised particles/molecules. Differences in these individual channels are often subtle and require analysis by machine learning software to interpret.

Future

Simple breath tests have already been adopted by the NHS. These include Exhaled Nitric Oxide (FeNO), which is used to indicate airway inflammation in asthmatics, and Urea breath test for carbon-13 as a non-invasive detector of Helicobacter pylori infection in gastritis, gastric ulcers and peptic ulcer disease. However, looking at VOCs in human breath with regards to COPD is proving to be more complex, which could reflect the heterogeneity of the disease. In addition, variability in medications and their effects on each patient's biochemistry could also influence VOCs (due to the differential effects on metabolic process between individuals). Even the lung microbiome and the inflammatory system may have an effect on VOCs. Research investigating the different bacteria found in both the lungs and the gut of humans has highlighted that these organisms also produce their own VOCs[12]. Christiansen and colleagues completed a systematic review of breath analysis and detection of VOCs in COPD. They reviewed 12 studies in COPD with samples sizes ranging from 22 to 222. They highlighted the fact that there was no standardised breath sampling procedure for COPD (four out of the twelve studies used an ion mobility spectrometer, two stated PTR-TOF-MS and the remaining six used GC-MS). Moreover, only four studies mentioned removing background room air. Statistical analyses were completed using a wide range of methods from simple univariate statistics to machine learning methods. Four studies relied on one single VOC, while the others used a combination. Only seven studies published the name of the VOCs investigated with the others simply publishing the raw data[13]. This lack of standardisation in VOC measurement could lead to difficulties for future VOC research. However, with the introduction of machine learning and new technologies, breath analysis will continue to evolve and may become a clinically useful adjunct to more traditional lung function tests in the diagnosis and management of COPD and other inflammatory lung diseases.

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ARTP AGM

Sovereign Suite, Birmingham Hilton Metropole

Chair: Julie Lloyd

Thursday 16th January 2020

Welcome

Julie Lloyd (JL), ARTP Honorary Chair, welcomed the audience that was more than 100 people and outlined the agenda for the AGM and the annual report that had been sent to all members prior to the AGM.

JL introduced all the Executive Board Members and thanked the Board and the Council Members for their work this year.

Membership numbers continue to grow with 102 new members in 2019 and an increase in ARTP sleep members.

JL advised that a new examinations format is being developed by the Education Committee, which is set to launch in November 2020.

Accounts

JL gave an overview of the accounts, which had been made available to members before the AGM, where there has been a small increase in income and expenditure with a stable surplus of income over expenditure. JL reminded those present of the membership categories that have voting rights (allied, associate or life member). All members present voted to accept the accounts with no objections.

Trustee Voting

The role of ARTP President was up for re-election and it was proposed that Dr James Hull would remain in post. All members present voted in favour of this with no objections so the nomination was accepted.

The role of ARTP Honorary Secretary was also up for re-election and it was proposed that Cara Roberts would remain in post. All members present voted in favour of this with no objections so the nomination was accepted.

Tobacco Policy

JL provided an overview of the proposed ARTP tobacco policy. The membership of approximately 105 voted in favour of this with no objections, so the policy was accepted.

Executive Committee Updates

JL outlined further committee changes with a new Standards Chair (Peter Moxon), Standards Vice Chair (Matthew Rutter) and Paediatrics Chair (Dr. Jane Kirkby). JL informed those present that Edward Parkes has stepped down as Education Vice Chair and welcomed any new volunteers to the ARTP to get in touch.

JL gave thanks to Ian Cliff and Paul Burns for all of their help in their Chair roles.

JL gave an overview of the work the ARTP has been involved in over the last year, particularly the Taskforce for Lung Health and STP Curriculum.

Association Updates

JL advised that the new ARTP website is due to launch on 1st February 2020.

JL informed the membership that ARTP membership is now on a rolling basis rather than a fixed term.

JL outlined the benefits of ARTP membership including joint membership with ERS and BSS as well as significant discount on courses and the annual conference.

JL informed that the updated ARTP Guidelines document is now complete and thanked those involved (Dr Karl Sylvester; Keith Butterfield) for their hard work with finishing this.

JL thanked all ARTP Committees for their continual hard work. JL gave thanks to the Events Committee for their hard work with organising the conference. JL also thanked EBS for their events and administrative support.

JL announced the 2021 conference will be held at Southport Conference Centre

JL advised that ARTP Past Chair, Karl Sylvester, is nominated as Chair for the 9.01 ERS Group and expressed support for this.

AOB

JL asked if there were any questions from the membership. No questions were raised.

Close

JL brought the AGM to a close.

Harry Griffin

Top Forum

A round-up of ARTP forum discussions since the December 2019 issue.

Title: Healthcare Science Associate/ Sleep Physiology

Date: 15/11/2019

Question: 1) Are there any Sleep departments that have had staff go through the Healthcare Science Associate apprenticeship. 2) Can anyone advise on a more appropriate route for training/ qualifications predominately in sleep physiology?

Some background: The department is trying to identify pathways for band 3 staff to progress to band 4. The department's current training pathway is to provide in house training to graduate students with the aim of undertaking the RPSGT exam. However, they have concerns that this approach will not enable professional registration via RCCP and AHS but the Healthcare Science apprenticeship is too lung function focused for their sleep only physiology department

Replies: A really detailed reply from an experienced physiologist who leads the apprenticeship degree course at UWE (Bristol) provided plenty of useful information on this problem. He stated that although year three students had a strong focus on sleep physiology, year one and two students are required to gain a significant amount of practical experience in lung function.

Recognising this apprenticeship was therefore not suitable for staff at sleep-only physiology departments the physiologist provided a list of alternative options which included:

- ⇒ ARTP courses - Basic & Advanced sleep course
- ⇒ ARTP certificates - Pulse Oximetry etc.
- ⇒ Regional meetings - South West and the recent Sleep Medicine, Wales - and there are others
- ⇒ Commercially supported courses. There are courses run by Philips, ResMed and F&P (Care conference) and probably others that are very useful and relevant

In addition to the RPSGT exam the physiologist stated there is a European equivalent and that the ERS is also developing sleep courses. Finally, the physiologist suggested a BSc in sleep physiology could theoretically be available in the future because there are already relevant modules in the Neurophysiology and Cardiology apprenticeship courses that could be added to the sleep elements in the current Respiratory/Sleep apprenticeship.

Title: Hypoxic Challenge Testing

Date: 20/11/2019

Question: Does anyone perform routine spirometry testing prior to a hypoxic challenge test (HCT)? I realise Diffusion tests could be useful, however I'm not sure how spirometry could?

Replies: Only one reply to this post and the physiologist clearly felt that additional lung function tests would not be beneficial. Indeed, they stated that patients with known respiratory disease who are on LTOT will already be known to have impaired lung function and that the HCT is a separate assessment used to specifically assess the requirements for O_2 during air travel or at altitude.

Title: Cheyne stokes respiration and central apnoeas

Date: 04/12/2019

Question: This physiologist took to the forum to ask for its collective wisdom in helping to determine the best choice of therapy (e.g. CPAP, BiPAP, ASV) for a patient with almost exclusively cheyne stokes respiration (CSR). More specifically they asked:

1) What guidelines or evidence do other departments and individuals use to determine a policy/pathway for these complex cases?

2) Has anyone heard of the "CAMS" study? I don't know if the abbreviation is correct but this study was referred to by one of the team as evidence that we shouldn't use NIV in CSR. I'm aware of the SERVE-HF and the CANPAP study but I'm unfamiliar with the other.

Replies: The first physiologist to reply did not directly answer any of the abive questions but provided their view on the cause, treatment and risk of treating CSR. Their understanding was that the cardiac failure and subsequent hypoxia causes unstable respiration and that the carotid body was key to this issue. They suggested that first line treatment is focused on the heart failure but if this was unsuccessful then ventilator support could be used to correct the hypoxia. However, they also stated they were aware that one theory for the negative outcomes of NIV in the SERVE-HF trial was that CSR is a protective mechanism and that over ventilating with NIV could be detrimental. Finally, the physiologist suggested CSR may not actually be more common but just identified more often due to the increased use of multi-channel polygraphy sleeps studies and better awareness of the condition.

A second physiologist posted a useful link to a recent review paper on central breathing disturbances (e.g. CSR, CSA etc) by the ERS and highlighted a flow chart that could be utilised.

Definition, discrimination, diagnosis and treatment of central breathing disturbances during sleep. European Respiratory Society Task Force: European Respiratory Journal 2016. http://erj.ersjournals.com/content/early/2016/12/05/13993003.00959-2016

Title: Downward drift in saturation

Date: 09/12/2019

Question: Is anyone aware of any guidelines for identifying downward drift in nocturnal saturation? At present we comment if there is noticeable downward drift in saturation but are not aware of any criteria to assess this?

Replies: The first of two replies suggested that the most useful measurement to report in these scenarios is the time spent below 90% S_pO_2. They also stated that clinicians at their Trust would consider nocturnal hypoxaemia when this value was greater than 20% of the study duration. The physiologist kindly performed a literature search but was unable to find any publications to provide support for this 20% value, other than it was predictive of surgical outcomes.

A second physiologist was in agreement with the first that the time spent below 90% S_pO_2 was an appropriate measurement to use when highlighting the reducing baseline S_pO_2 but that he would also add a comment on the downward drift in the report. They suggested that this downward drift in S_pO_2 could be due to medication wearing off and also highlighted that this lowering of the baseline S_pO_2 can then cause the ODI/AHI to be overestimated.

Title: DVLA forms

Date: 31/12/2019

Question: How do you deal with payments for DVLA forms? Currently we fill them in and our consultant counter signs them, we then invoice the DVLA asking for the cheque to be paid to our charitable funds. We have now started receiving letters saying that payment will only be made to the doctor counter signing the document.

Replies: Just one reply, with the physiologist stating they follow the same process described above but

Harry Griffin

Top Forum

that the finance department invoice the DVLA with the funds then going directly into the department's budget. They were unaware of the DVLA making any changes.

Title: Ambulatory O_2

Date: 30/12/2019

Question: Have there been any updated O_2 prescription guidelines published since the BTS 2015 paper, especially with regards to ambulatory O_2?

Replies: Just the one reply, but a nice clear answer stating that there had been no update since 2015 but that BTS are planning to review their guidance this year. In the interim they have produced a Quality Standard document of which one of the standards concerned ambulatory O_2 although this only reiterated information in the 2015 guidelines. However, the physiologist did report that in the updated COPD guidelines by NICE, O_2 is no longer recommended to current smokers.

Title: Methacholine or Histamine challenge suppliers

Date: 06/01/2020

Question: I am looking to add either histamine or methacholine challenge testing to our service. I would be really grateful for details of suppliers for either drug and if possible cost, so that I can take this to my pharmacy department.

Similar questions have been asked on the forum in recent years but this time it indirectly started an interesting debate between two experienced physiologists regarding the use of different challenge tests in investigating asthma.

Replies: The first physiologist to reply echoed previous posts on the forum by stating their department had changed from histamine to methacholine last year. Their usual histamine supplier stopped providing the solution and other suppliers were deemed too costly, whereas methacholine was much cheaper. The physiologist suggested that methacholine had several benefits over histamine which included; fewer side effects, patients not needing to stop anti-histamines and a recent guideline paper focused on methacholine by the ERS/ATS (2017).

Another physiologist (named physiologist A for ease of understanding) suggested that the indirect challenge test using Mannitol could be used as an easier and quicker alternative to histamine/methacholine tests. They did however acknowledge a limitation is that patients can cough when inhaling the powder.

It emerged that the physiologist who posted the initial question had asked about histamine/methacholine suppliers because they were moving away from using mannitol tests because they believed the recent NICE guidelines for asthma had removed it. This reply prompted physiologist A to suggest that NICE guidance can sometimes be contradictory to guidance from other professional bodies and common sense. As such, Physiologist A had therefore decided to continue to use mannitol and stated "*the main usefulness of the mannitol challenge is that it allows, in patients who have current symptoms of asthma, to confirm or exclude the presence of the disease. However, only a negative methacholine result is particularly valuable to rule out a diagnosis of asthma and is therefore non-specific. From a pragmatic point of view there is generally good agreement between the 2 methods – why would you want the more expensive and more difficult to obtain/use method (methacholine challenge)?*". The physiologist finished by stating "*Nobody has ever given me a good explanation as to why a direct method of challenge is 'better' at deciding whether someone has asthma or not? I'm happy to be*

educated".

Another experienced physiologist (named as Physiologist B), provided a link to a very relevant review paper on bronchial hyper-responsiveness (BHR)

J. Borak, R. Y. Lefkowitz. Bronchial hyperresponsiveness. Occupational Medicine, Volume 66, Issue 2, March 2016, Pages 95–105, (https://academic.oup.com/occmed/article/66/2/95/2750597).

This paper compared the different types of bronchial challenge tests available and their use in investigating different respiratory conditions. Physiologist B was in agreement with Physiologist A that when asthma is the likely cause of symptoms then a referral for a mannitol test is sensible. However, they disagreed with a comment from physiologist A that could have been interpreted as suggesting this paper described BHR as always a feature of asthma. To this end, physiologist B highlighted a number of paragraphs from the paper that suggested BHR can occur in non-asthmatic patients and as such felt that a direct challenge test remains a very useful test when the referral is for anything other than suspected asthma. A selection of the relevant paragraphs are:

⇒ *However, BHR is also found in a spectrum of other lung diseases from chronic obstructive pulmonary disease (COPD) to cystic fibrosis*

⇒ *...often detected in atopic individuals, in patients with rhinitis but without pulmonary symptoms, in smokers and ex-smokers, after respiratory infections and following acute inhalation exposure to irritant chemicals*

⇒ *BHR testing has played an important role in the diagnosis of airway diseases such as asthma, reactive airway dysfunction syndrome (RADS) and COPD*

⇒ *As noted above, BHR is often regarded as a defining feature of asthma. That understanding has led to the overwhelming, but incorrect, generalization that a positive response to BHR testing is diagnostic of asthma*

Title: Freedom of Information Request

Date: 09/01/2020

Question: Have other services been receiving freedom of information (FOI) requests for info on sleep equipment? We received a request asking for very specific information on our sleep services and the equipment. A selection of the questions asked were:

⇒ *How many paediatric patients with suspected sleep-disordered breathing do you diagnose per year? A) Cardiorespiratory Polygraphy, B) Polysomnography*

⇒ *How many paediatric patients do you have on waiting list for an overnight sleep study? A) Cardiorespiratory Polygraphy, B) Polysomnography*

⇒ *Who are your suppliers of cardioPSG and PSG devices?*

⇒ *How many beds do you have for overnight sleep studies?*

⇒ *What is the percentage of patients who return for a second or more sleep study?*

Replies: A useful reply from an experienced Physiologist reminded us that anybody can make a FOI request and by law your Trust needs to respond to this appropriately. Indeed, it could be a newspaper researcher or a commercial organisation doing market research. The Physiologist also described how the private sector could take advantage of this law as "the 'pseudo-market' of the publically funded NHS is wide-open to competitors in the private sector exploiting what they would describe as 'commercially sensitive' information".

Another senior sleep physiologist stated that their department had received a similar FOI recently. They suspected it was an external company asking for information and not someone in the NHS who would likely have made direct contact. The physiologist did suggest it could have been someone utilising the FOI to effectively, albeit 'sneakily' collect data for research. Presumably with tongue-in-cheek the previous reply mentioned that maybe ARTP could use FOI for its next ARTP survey! No doubt it would bring about a large response rate but as highlighted by the second physiologist, replying to a FOI request is time consuming for departments and there are tight deadlines to be met.

How it Works

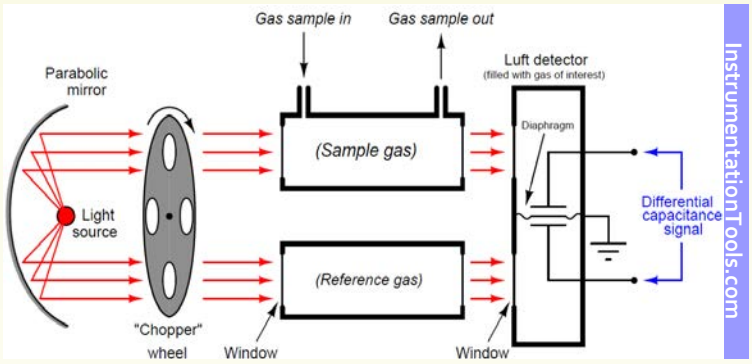
By Kevin Hogben

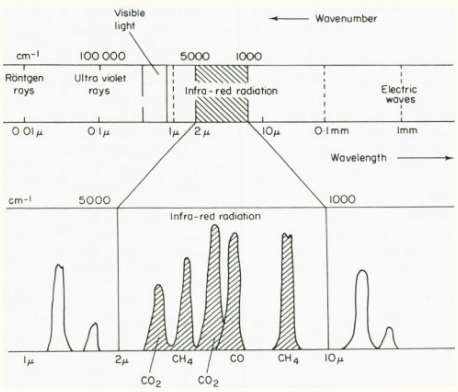
Gas Analysis in Respiratory measurements

All gases have properties that enable them to be measured, these techniques involve heat, optical, chemical and even magnetic properties.

Infrared

Infrared is the method by which a gas absorbs the energy generated by a heat source. The amount of absorption can then be translated into the partial pressure and gas percentage. Infrared is most commonly used to measure gases such as Carbon Dioxide, Carbon Monoxide and Methane. Other gases that fall within the infrared spectrum (e.g. Acetylene and alcohols) have their signals removed by filters, if possible. In early systems this was achieved by use of a reference chamber containing 100% of the gas to remove, then amplifying the signal to use only the gas to measure. More recent systems achieve this with the use of an optical filter that filters specific frequencies to ensure the analyser is specific to the required measurement gas. Analysers are inherently non-linear therefore the 10% to 90% rise of the analyser is typically used for the measurements. Originally twin beam analysers were used with the infrared heat source in a parabolic reflector interrupted by a chopper motor generating heat down both tubes to the "luft" detector, this was a diaphragm forming part of a variable capacitor, the heat travelling to the detector on one side would be absorbed by the gas to measure i.e. one side was hotter than the other and the heat would then displace the diaphragm affecting the capacitance thus changing the tuning of a radio frequency circuit producing a voltage output scaled to the gas to be measured. Much the same in principle to a Crystal Radio set. The disadvantage of this design was the large dead space of the analyser and this influenced how much sample volume was needed to fill the analysis cell during the period of measurement.





The more modern Infrared analyser is a single beam analyser with smaller dead space, the chopper motor is either designed as an alternating signal / no signal two function rotating wheel, or in the case of Multigas analysers to have multiple windows with a Reference then an optical filter for each gas to measure. The "Luft" detector has been replaced with a solid state detector and

an alternative to the chopper motor and wheel is to switch on and off the infrared light source.

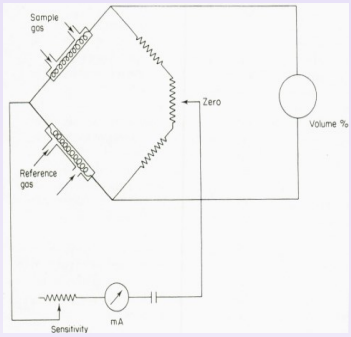
Chemical cell

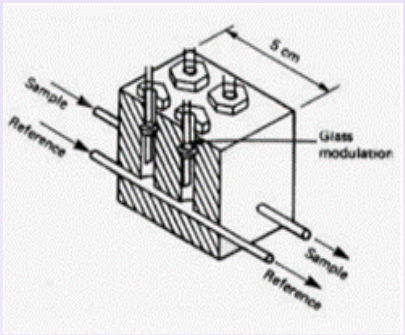
The alternative to the infrared cell is the Chemical cell, which uses a chemical that reacts with the test gas to provide an electrical output proportional to the gas measured. This type of cell typically remains linear for 2-3 years of life, depending on the amount of exposure to the gas it measures.

Original twin beam analyser

Thermal Conductivity

This technique was widely used post second world war for the measurement of the Carbon dioxide emitting from the industrial chimney's in Germany and hence named the *Katharometer*, This principle is based on the *Wheatstone bridge,* a resistor network with one "arm" in the path of the gas to measure and a reference "arm". The bridge would be placed out of balance by the change in resistance proportional to the change in temperature, this resulting flow of current could then be scaled in the gas to be measured.





The Wheatstone bridge construction. The block is constructed from Brass for good temperature stability, with a rapid Helium Katharometer it is necessary to build in intelligence to regulate for Temperature, Flow and Pressure in the measuring cell. The analyser is used in the 10% to 90% operating range where the linearity is the best.

Thermal conductivity of gases with respect to air

	At 0°C	At 100°C
Air	1.00	1.00
Argon	0.68	0.70
Carbon Dioxide	0.61	0.70
Carbon Monoxide	0.96	0.96
Helium	5.97	5.55
Hydrogen	7.15	6.90
Nitrogen	0.995	1.996
Oxygen	1.013	1.014
Water Vapour	-	0.78

Whilst the design was able to track the slow changes in the level of Carbon Dioxide, in the medical sector it became a more useful measure of another thermally conductive gas, Helium, although this technique also requires correction by removal of other gases. This was traditionally performed with Chemical absorbers, Calcium Chloride or Drierite to remove water vapour and Soda lime to remove Carbon Dioxide. With the move to real-time gas analysis it was not possible to continue this approach and today therefore it is more common to use a permapure nafion moisture exchange line to equate the water vapour plus the Carbon Dioxide

CONCEPTS OF ANALYSER PRINCIPLES: The principle of measurement is based on the partial pressure; the flow and pressure in the cell is designed to be constant. Excessive pressure in the cell causes compression of the gas and the extra molecules will result in over reading the gas, Rarefaction by a vacuum effect on the line will stretch the gas reducing the molecules and causing an under reading of the measured value.

LINEARITY OF GAS ANALYSERS: This is simple by applying Boyles Law, most commonly performed under serial dilution, this is where if we know the initial volume of the gas and then dilute by a second volume of air, it is possible to calculate or plot the final value expected against the value recorded and to calculate Error%.

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O1 - RELATIONSHIP BETWEEN VOLATILE ORGANIC COMPOUNDS IN BREATH DETERMINED BY PROTON TRANSFER MASS SPECTROMETRY, CLINICAL CHARACTERISTICS AND AIRWAY INFLAMMATION IN COPD

Mrs Liesl Carr[1], Mr Luke Bryant[2], Doctor Ahmed Yousef[1], Miss Rebecca Cordell[2], Mr Micheal Wilde[2], Professor Salman Siddiqui[1], Mr Paul Monks[2], Professor Christopher Brightling[1]

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2. *Department of Chemistry, University of Leicester, Leicester, United Kingdom*

Background

Chronic obstructive pulmonary disease (COPD) is a heterogeneous condition. Breathomics presents an opportunity to phenotype this heterogeneity but how breath volatile organic compounds (VOCs) relate to clinical features, airway physiology and inflammation is uncertain.

Methods

We undertook a single centre prospective study in subjects with moderate to severe COPD. We assessed 379 breath samples obtained at stable visits. The breath VOCs were examined using Proton Transfer Reaction-Time Flight-Mass Spectrometry (PTR-TOF-MS). Principal component analysis (PCA) and partial least squares discriminant analysis (PLS-DA) models were undertaken to determine whether there were distinct VOC profiles associated with spirometry, plethysmography lung volumes, gas transfer, symptoms (mMRC and CAT questionnaires), sputum eosinophils (< versus ≥1%) and neutrophils (< versus ≥61%).

Results

34 COPD subjects were studied of which 8 were women. The subjects had a mean age 70 (66-74) years and FEV_1 52% predicted (32.2-72.3%). There were no distinct VOC breath profiles that were associated with airway physiology or symptoms. The sputum eosinophil and sputum neutrophil cut-offs did identify distinct profiles with a receiver operator characteristic (ROC) curve area-under-the-curve (95% confidence intervals) 0.84 (0.77-0.86) and 0.80 (0.69-0.81) respectively.

Conclusion

VOC breath profiles are related to airway inflammation but not physiology or symptoms in COPD.

O2 - A CLINICAL QUALITY IMPROVEMENT PROJECT ON ASSESSING CO-EXISTING NOCTURNAL HYPOVENTILATION ALONGSIDE OBSTRUCTIVE SLEEP APNOEA

Miss Shirley Coelho[1], Mrs Elizabeth Green[1], Mr Allan Alhelou[1], Mr Rahul Mukherjee[1]

1. *University Hospitals Birmingham, Bordesley Green, United Kingdom*

Background

Nocturnal hypoxia and obstructive sleep apnoea (OSA) are associated with increased risk of atrial fibrillation, hypertension and increased risk of diabetes. However, OSA is typically treated as an isolated pathology. An original survey in our department showed that, due to lack of clear guidance, failure to recognise hypoventilation leads to underdiagnosing conditions like OSA/COPD and OSA/OHS overlap[1].

Aim

To assess how many patients with a diagnosis of obstructive sleep apnoea that spend > 20% of the night with SpO_2 below 90%, were followed up with an overnight oximetry once on CPAP. This is to ascertain the need for NIV and/or supplemental oxygen.

Method

We performed an internal audit to check how many patients with severe OSA were followed up with overnight oximetry once settled on CPAP. Patients that had an AHI > 30 and SpO_2 < 90% for more than 20% of the night were included.

Results

A total of 1632 studies were performed between July 2018 and July 2019. 382 (23%) had severe OSA; in this severe OSA group, 174 individuals (45%) spent > 20% of the night with SpO_2<90% and 131 (34%) spent >30% of the night SpO_2 < 90%. In the group of patients with a significant time spent under 90%, only 15 individuals (8%) were followed up with overnight oximetry on CPAP and 4 (27%) of those were managed with CPAP pressure increase and still showed evidence of hypoventilation.

Conclusion

At the time of the first audit cycle, none of the patients that fit the above criteria were identified. By raising internal awareness during departmental meetings, there was some recognition of nocturnal hypoventilation. Through the period of the second audit cycle, the number of overnight oximetry tests on CPAP increased by 62%. Further guidance on how to manage this group of patients is needed.

Reference:

1. Cachada N, Daniels M, Chakraborty B, et al. The strength of association of nocturnal hypoventilation with severity of sleep apnoea. ERJ 2016; 48:PA2200

O3 - IMPACT OF A MULTIDISCIPLINARY APPROACH TO DELIVERING ACUTE NIV IN A LARGE TEACHING HOSPITAL.

Mr Edward Parkes[1], Mrs Joanna Shakespeare[1], Dr Asad Ali[1]

1UHCW, Coventry, United Kingdom

Introduction

Acute non-invasive ventilation (aNIV) is a well evidenced treatment for acute hypercapnic respiratory failure (AHRF) in COPD and other conditions including obesity hypoventilation syndrome, restrictive chest wall conditions and neuromuscular diseases. Within our service we recognised similar challenges and outcomes highlighted by NCEPOD's 'Inspiring Change' document. In response to this and utilising BTS Quality Standards, we undertook a quality improvement project (QIP), introducing a multidisciplinary aNIV team including the skills of Clinical Scientists, Physiologists, Physiotherapists and Nurses. We present results from our first dataset.

Methods

This is a retrospective study of patients who commenced aNIV according to local policy at a large university teaching hospital over a 6-month period. Outcome variables were based on BTS Quality Standards and reviewed using NCEPOD audit toolkit. In addition, physiology data, inpatient mortality, 30-day mortality and readmission rates were recorded.

Results

Our patient cohort (47) was predominantly COPD patients (79%) with a mean pH of 7.25 (NCEPOD cohort; COPD 69%, pH 7.25). Mean referral to mask time was 22 minutes, with 80% seen and treated by aNIV team within 1 hour (30% prior to aNIV team). In total 30% of patients had a pre-NIV pH <7.25 and 16% <7.15. ABG sampling at 1hr of NIV was completed in 97%. A total of 85% had an improved pH and 87% pC02 at 1hr of NIV (range .01-.26; .16-6.29kpa, respectively) with complete reversal of respiratory acidosis in 17% of patients.

In-patient mortality was lower than NCEPOD cohort and our previous audit (16%; 35%; 28%, respectively), 30-day mortality was 0% with a 14% 30-day re-admission rate. Assessment against BTS Quality Standards are shown in Table 1.

Discussion

Our data shows that an aNIV MDT utilising NCEPOD toolkit is able to deliver BTS quality standards to a large percentage of patients and contribute towards a reduction in inpatient mortality. A well-defined aNIV pathway, dedicated on-call rota, specific proforma and robust staff competency framework contribute towards achieving these outcomes. Future research is required in order to fully understand the mechanisms by which further improvements in patient outcomes can be achieved.

BTS Quality Standards Domain	Patients Achieved (%)	Performance Status
Treating the right patients: Is NIV indicated?	96	Amber
Making a ceiling of treatment decision or escalation plan before starting NIV	87	Amber
Documenting NIV settings and the adjustment in settings in response to new information	100	Green
Starting NIV within 60 minutes of the decision to treat with NIV	80	Amber
Continuous monitoring of the patient over the first 24 hours or until the initial respiratory acidosis has resolved	75	Amber
Staff training and competency	100	Green

Table 1 - British Thoracic Society (BTS) Quality Standards

O4 - VALIDATION OF NITRIC OXIDE TRANSFER FACTOR PREDICTED EQUATIONS AND THE IMPACT OF POSTURE.

Mr Matthew Austin[1,2], Mr Laurie Smith[1,3], Dr James Eaden[1,2], Dr Helen Marshall[1], Professor Jim Wild[1]

1. *The University of Sheffield, Sheffield, United Kingdom*
2. *Sheffield Teaching Hospitals NHS Foundation Trust, Sheffield, United Kingdom*
3. *Sheffield Children's Hospital NHS Foundation Trust, Sheffield, United Kingdom*

Introduction

Predicted values for the combined simultaneous measurement of TL_{NO} and TL_{CO} (TLNO,CO) are available[1,2]. We aimed to validate these equations in a previously untested population.

Increasingly lung function measures are compared to functional magnetic resonance imaging obtained with the patient supine. We aimed to examine the effect of postural changes from seated to supine on TLNO,CO.

Methods

98 healthy volunteers performed spirometry and TLNO,CO, a subgroup additionally performed TLNO,CO whilst supine. Measured TLNO,CO values were compared to predicted[1,2]. A mean z-score and standard deviation (SD) of 0 and 1 respectively indicated a good fit to predicted values. Bland Altman plots assessed agreement between measured and predicted. Percentage change was used to identify difference between seated and supine values.

Results

Volunteers were aged 18.5-82.8 years. Using GLI spirometry and TL_{CO} equations, measured values fit well against the normal distribution (mean (SD)) z-score; FEV_1 -0.1(0.9), FVC=0.2 (0.8), FEV_1/FVC=-0.4(0.94) and TL_{CO}=-0.2(0.7). Using Zavorsky equations[1], mean(SD) z-score; TL_{NO}=-1.6(0.7), TL_{CO}=-1.0(0.7). Using Munkholm equations[2], TL_{NO}=-1.4(0.9), TL_{CO}=-1.2(0.9). Measured TLNO,CO compared to Zavorsky predicted[1] was lower with a bias of -11.0 and -1.3mmol.min.kPa for TL_{NO} and TL_{CO} respectively. Measured TLNO,CO compared to Munkholm predicted[2] was lower with a bias of -6.3 and -1.3mmol.min.kPa for TL_{NO} and TL_{CO} respectively. 31 subjects performed TLNO,CO whilst supine. Both TL_{NO} and TL_{CO} values significantly increased ($p<0.001$) when supine by 3% and 7% respectively.

Conclusion

Published predicted equations for TLNO,CO over-estimate gas exchange measurement in this healthy population and therefore may not be appropriate for local clinical use.

TLNO,CO increased when supine suggesting comparisons between seated lung function and supine radiologic images should be made with care.

References

1. ZAVORSKY, G. S., HSIA, C. C. W., HUGHES, J. M. B., BORLAND, C. D. R., GUÉNARD, H., VAN DER LEE, I., STEENBRUGGEN, I., NAEIJE, R., CAO, J. & DINH-XUAN, A. T. 2017. Standardisation and application of the single-breath determination of nitric oxide uptake in the lung. European Respiratory Journal, 49.
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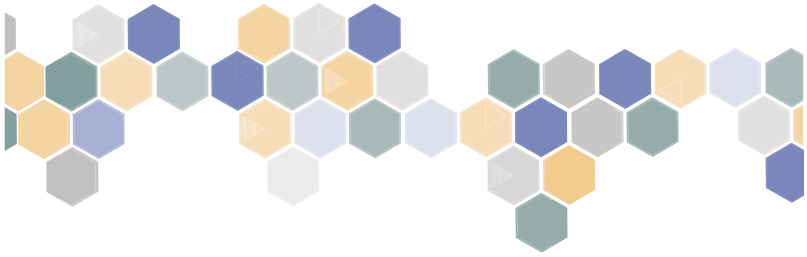

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* AM Respir Crit Care Med Vol 163 - Pp 1457-1461, 2001 click here for full article

P02 - CARDIOPULMONARY EXERCISE TESTING SERVICE UTILISATION: SERVICE DEVELOPMENT

Mr Max Thomas[1], Dr Vicky Moore[1], Ms Shirley Coelho[1]

1. *University Hospitals Birmingham, Birmingham, United Kingdom*

Introduction

CPET is used as a preoperative screening tool to assess fitness; as a disease monitoring tool to determine functional limitation and treatment response; or as a diagnostic tool to identify the cause of breathlessness or exercise intolerance. Use of CPET as a diagnostic tool can pre-empt invasive, expensive and potentially unnecessary assessment without definitive diagnosis (Thing et al. Thorax 2011; 66 (4): A144). An audit in 2018 highlighted that the service at Birmingham Heartlands Hospital was underutilised for diagnostic purposes. Efforts were made to promote the service through initiating joint clinics, attending MDTs, giving talks in local research meetings/journal clubs.

Methods

We conducted a retrospective analysis of CPET referrals between June 2018 and May 2019, and compared with those of the previous 12 months. The source of referral and clinical indication were recorded and presented.

Results

Total referrals for CPET were 456 in 2018-19 compared to 307 in 2017-18 (see figure) indicating a 32.7% increase. The majority of referrals were for surgical disciplines rather than medical disciplines in both time periods (326 vs 130 in 2018-19; 268 vs 59 in 2017-18); however the proportion of tests for diagnostic purposes has increased by 9.3% (28.5% in 2018-19 vs 19.2% in 2017-18). Vascular surgery was the largest source of referrals in both time periods (47.6% of total referrals in 2018-19; 46.8% in 2017-18). In the 2018-2019, the total number of CPET referrals from cardiology and respiratory has increased by 327% and 197% respectively. Referrals from cardiology now equate to 7.9% of all referrals to the CPET service, and respiratory equates to 20.4% of all referrals.

Discussion

The CPET service has experienced a large increase in the number of referrals after continued effort to increase service uptake. Preoperative assessment remains the primary referral type – predominantly vascular surgery. The effort to improve utilisation of CPET for diagnostic purposes has improved the rate of referral from cardiology and respiratory medicine, disciplines that would benefit most from the service. The continued growth of the service is evident. The future growth will rely on development of the workforce and continued promotion of the service.

P03 - AUDIT OF GP SPIROMETRY SERVICES IN CHESHIRE WEST

Miss Marie Hardy[1]

1. *Countess Of Chester, Chester, United Kingdom*

Aim

To ascertain which GP practices offer a spirometry service, how frequently spirometry is performed and the qualifications/ registration of staff performing spirometry in comparison to national standards.

Method

Audit approval was obtained from the Clinical Lead and the Countess of Chester R&D department, a questionnaire was developed and sent to all 33 GP practices in Cheshire West to be completed and returned to the R&D department.

The audit looked at 4 elements 1.Does the practice perform spirometry testing, 2. Which Health Care professionals (HCP) perform the tests, 3. Calibration of equipment, 4. Interest in a community spirometry service/ training information

Results

Of the 33 questionnaires sent 16 were returned (52% response rate)

All practices stated that they provided a spirometry service. However; the frequency in which spirometry was performed varied from daily (56%), weekly (33%), monthly (6%) and adhoc (25%).

From those that completed questionnaires, a total of 23 HCP performing spirometry were identified, 20 practice nurses and 3 health care assistants. None of the practices had GPs or any other HCP performing spirometry. It was also found that only 9 of these healthcare providers had received training within the last 3 years and furthermore only 3 of these were on the ARTP spirometry register (13%). See figure 1

The calibration and/or verification of the equipment used in the GP practices is variable between the practices from daily to never.

90% of the practices would be interested in a community based spirometry service overseen by COCH

Discussion: From the study it can be seen that the standard of training of those performing diagnostic spirometry is poor with only 40% of those that replied having received any training in the past 3 years and currently only 3 HCP from our responding practices are on the ARTP register of certified spirometry providers. Cheshire west CCG estimates approximately 2000 diagnostic spirometry tests are performed each year across the area.

Following on from this audit a community spirometry service has now been developed and is in the process of being implemented in stages across the Cheshire west area.

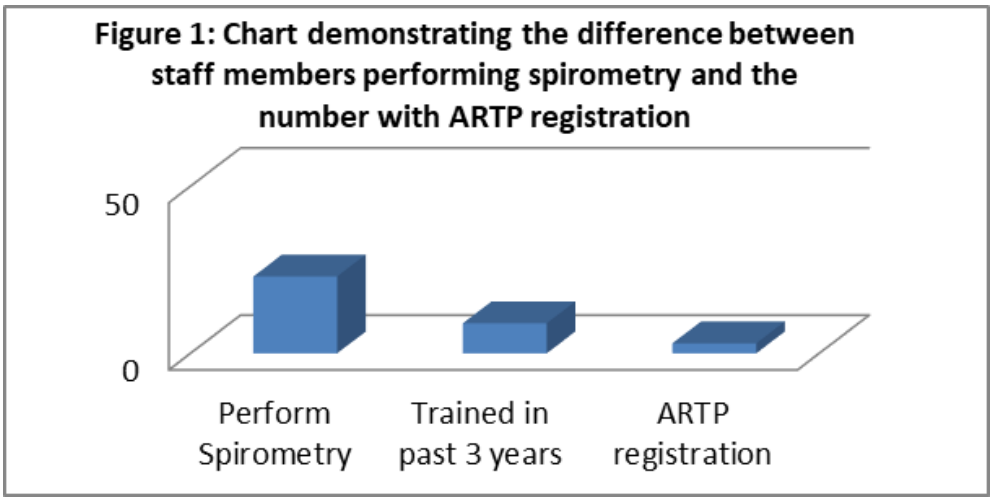

Figure 1: Chart demonstrating the difference between staff members performing spirometry and the number with ARTP registration

P04 - PCT COMMUNITY SPIROMETRY - A PHYSIOLOGY LED SERVICE EVALUATION.

Mrs Emma Munro[1], Mrs Charlotte Montague[1], Mr Ian Cliff[1]

1. *University Hospital Of North Mindlands, Stoke-on-trent, United Kingdom*

Aim/Introduction

To evaluate the physiology led spirometry service provided for the community respiratory team (CRT) on behalf of GP practices within the North Staffordshire CCG. Appointments for Spirometry are booked within 2 weeks of referral. Patients attend a local health centre. Spirometry, MRC score, pulse oximetry and inhaler technique are assessed.

Methods

A six month period was evaluated. Utilisation of the service capacity was addressed. The classification of spirometry and total number of referrals into secondary care were measured. A comparison of a current diagnosis and any new diagnosis were also analysed.

Results

Spirometry clinics are held at 5 locations with clinic utilisation at 78% of capacity. This was largely due to DNA's (20%) and a small portion of last minute cancellations (2%). 307 (60%) of the 513 patients seen had 'normal' spirometry. A referral to a tier 4 service was advised in only 9% of cases. The remaining 81% of patients were managed within a tier 2/3 service. What is clear is that a 'label' of a diagnosis is less important than the severity of abnormality present. Referral rate increased with deteriorating spirometry. In 4% of cases where the spirometry was considered 'normal', a referral was still advised for a number of reasons, thus highlighting the importance of measuring additional outcomes in conjunction with spirometry testing.

Conclusion

The high number of DNA's needs to be improved. Following the audit, the CRT admin will be sending an 'opt-in' appointment letter in which patients contact them to make an appointment that is convenient. The service will be re-audited in 3 months' time to gauge progress. The spirometry service appears to provide a cost effective approach in which unnecessary referrals into secondary care are avoided; whilst patients that require further management than that offered by their GP they remain under the tier 3 CRT.

P05 - EVALUATION OF THE GROWTH AND DEVELOPMENT OF A NEW SOUTH LONDON PAEDIATRIC RESPIRATORY PHYSIOLOGY SERVICE

Miss Tara Goddard[1], Mrs Sara Parsons[1]

1. *St Georges Hospital NHS Foundation Trust, London, United Kingdom*

Aim

Evaluation of the growth and development of a new South London paediatric respiratory physiology service

Methods

Test type, number performed and sleep referrer information was collected retrospectively between January 2015 and June 2019 from hospital electronic record systems.

Results

9786 lung function tests were performed. Spirometry yielded the largest number of tests (4645) with Fractional exhaled Nitric Oxide and reversibility testing at 50.6%, which relates to our one-stop clinic service. Specialist tests have remained low, reducing from 2.67% to 0.86%. A plateau for number of lung function is starting to emerge.

Total number of sleep studies increased by 282% in first 6 months of 2019 when compared with 2015 total. Pulse oximetry studies accounted for 42% of total tests in 2019, of which 46% were referrals from ENT services. External ENT referrals have steadily increased, suggesting increased awareness of service and implementation of the tonsillectomy guidelines. Complex respiratory sleep studies have increased. Staffing levels increased in 2018 from 0.5 to 1.5wte, coinciding with the largest increase in number of test performed between years.

Conclusions: The review demonstrates significant demand on a South London paediatric physiology service highlighting the importance of regular service review and recognising opportunities for further development. Considerations for future exponential growth include evaluation of peripheral services, clinic capacity, space, equipment availability and number of staff. Lower than expected numbers for full lung function and specialised tests, given the increase in specialised clinics, demonstrates underutilisation. This suggests the need for further education, awareness of the range of physiological tests already available and tests which could be implemented such as hypoxic challenge testing.

	2015	2016	2017	2018	2019
Type of Test	Number of tests performed				
PSG	8	25	56	63	52
TOSCA	105	108	195	275	131
Overnight Pulse Oximetry	0	0	6	174	136
Spirometry	710	937	1053	1279	669
Reversibility	138	159	142	273	122
FeNO	629	755	957	1160	580
Full Lung Function: *Spirometry *Gas Transfer *body plethysmography	41	30	34	34	12
Specialised Tests: *STEP TEST *Nasal NO *Muscle Pressures	14	17	8	24	9
Type of referrer	Percentage of referrals from total number of sleep studies				
Respiratory	21%	46%	60%	54%	48%
ENT	43%	30%	24%	20%	26%
External ENT	9%	10%	5%	13%	20%
Other	27%	14%	13%	13%	5%

P06 - BRONCHOPROVOCATION TESTING IN PATIENTS WITH ASTHMA-TYPE SYMPTOMS: WORTH TAKING A BREATH IN?

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Background

Direct bronchoprovocation testing (BPV) has an established role in the assessment of asthma-type symptoms[1]. Measurement of FEV_1 following exposure to escalating doses of inhaled histamine or methacholine can be used to assess the presence of lower airway hyper-responsiveness (AHR). Some centres have used this test to evaluate the presence of extra-thoracic airway hyper-responsiveness (EAHR), based on changes in the inspiratory flow[2]. We have utilised this approach at the Royal Brompton Hospital (RBH) for several years and the aim of this work was to assess the value of obtaining inspiratory flow measures during BPV.

Methods

Data was retrospectively evaluated from individuals who underwent BPV with histamine (Jul '14 – Mar '15) or methacholine (Oct '18 – Sept '19). AHR was defined by a 20% dose-responsive fall in FEV_1 (PC20FEV1) in response to ≤8 mg/ml histamine or methacholine. EAHR was defined as a 25% reduction in FIF_{50} (PC25FIF50) in response to ≤8 mg/ml histamine or methacholine, or ≤16 mg/ml. Symptoms were evaluated at each dose with a Borg score ≥3 taken as positive.

Results

We studied 142 patients; 65% (n=92) underwent histamine BPV (mean ±SD; age 45.6 ± 16.4 years, BMI 28.3 ± 6.1 kg/ m2, 70% female, n=64) and 35% (n=50) underwent methacholine BPV (mean ±SD; age 40.2 ± 13.8 years, BMI 27.0 ± 5.7 kg/ m^2, 80% female, n=40). For the patients tested with histamine evidence of AHR was found in 7 patients (7.6%) and EAHR in 10 patients (10.9%). Of the latter group, EAHR was found at ≤8 mg/ml in 5 patients (50.0%) and at ≤16 mg/ml in 5 patients (50.0%), and in 4 patients (40.0%) this was in a dose-responsive way. Of the 142 patients, 42 (45.7%) reported symptoms and in 34 (81.0%) of these, symptoms were dose-respondent (worsened through the test). The prevalence of AHR, EAHR and symptom development was similar with methacholine BPV. Patients with evidence of EAHR with histamine were older when compared with the methacholine group (40.9 (standard deviation 14.2) v 31.2 (17.0) years; unpaired t test: P=0.26). Those with EAHR in the histamine group had a slightly higher BMI (27.9 (SD 6.4) v 25.8 (1.3) kg/ m^2; Mann-Whitney U test P=0.68).

Conclusion

The prevalence of AHR and EAHR to direct BPV agents is similar and approximately 1 in 10 results was positive. Despite this, almost half of patients developed respiratory symptoms during BPV.

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P07 - 200 MCG VERSUS 400 MCG BD - IS THERE A REAL DIFFERENCE?

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The use of bronchodilator therapy is essential in assessing the potential reversibility of airway function. The choice of which bronchodilator type and the dosage are two key factors in determining the overall response. In this study we have retrospectively analysed data in a group of patients given 200 mcg of salbutamol and in a separate group given 400 mcg. The response to the difference doses was assessed using the change in FEV_1 and in FVC as a percentage of predicted value, thereby standardising for age, height and sex.

2466 subjects (45% Male) aged 53 ± 17 years were assessed for 200 mcg. Mean FEV_1 pre-BD was 2.4 ± 0.96 L rising to 2.5 ± 0.99 L post BD. The %predicted change was 2.7 ± 7.5%. For FVC the values were 3.4 ± 1.16 L rising to 3.45 ± 1.17 L. The %predicted change was 1.3 ± 9.8%.

For the 400 mcg group 159 subjects were assessed (48% male), aged 55 ± 16 years. Mean FEV_1 pre-BD was 2.36 ± 0.87 L rising to 2.46 ± 0.9 L post BD. The %predicted change was 3.7 ± 6.5%. For FVC the values were 3.4 ± 1.04 L rising to 3.48 ± 1.08 L. The %predicted change was 1.53 ± 8.8%.

There was no significant difference between the responses for either FEV_1 or FVC when using the change as a %predicted. Within the limitations data analysis, these results suggest that there does not appear to be any significant advantage of giving 400 mcg as compared to 200 mcg. Ideally a direct comparison of doses should be undertaken in the same subject, on different days, which might provide a better insight as to the importance of BD dose.

P08 - A RETROSPECTIVE ANALYSIS OF PATIENTS REFERRED FOR TWO DIFFERENT BRONCHIAL CHALLENGE TESTS BETWEEN JANUARY 2016 AND AUGUST 2018.

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Background

Asthma affects over three hundred million people worldwide (GINA, 2018). It is characterised by airflow obstruction, which varies over time and in severity, with concomitant airway inflammation and hyperreactivity (an exaggerated response to a range of allergic and environmental stimuli) (BTS/SIGN, 2016; Busse, 2012). Bronchial challenge tests (BCTs) are recommended by national and international clinical guidelines for the diagnosis of asthma. The two investigations most commonly used to identify airway hyperreactivity (AHR) in clinical practice are methacholine and mannitol bronchial challenges. Concern over the diagnostic accuracy and reliability of bronchial challenge tests within the respiratory physiology department provided the driver for this project.

Aims

To characterise and compare patients referred for methacholine or mannitol challenge tests over 24-months. Objectives were to analyse data within and between groups to detect potential predictors of reactivity and develop an algorithm for selecting the best bronchial challenge method, based on patients' clinical characteristics.

Methods

Demographic data, bronchial challenge, spirometry, blood eosinophils, IgE, F_ENO, asthma medication, symptoms, reason for referral, and final diagnosis, were obtained for 72 adult patients referred for bronchial

challenge. Patients were grouped into, non-reactive (n=45), methacholine-reactive (n-18) and mannitol-reactive (n=9). Data were analysed for associations with reactivity.

Results

Significant associations were found between shortness-of-breath (p=.013), cough (p<.001) use of ICS (p=.009), SABA (p=.015), oral steroids (p=.022), and methacholine-reactivity. Lower FEV_1 % pred (p=.003), FEV_1/FVC (p=.029), and PEF % pred (p=.020) were significantly associated with mannitol-reactivity. Reactive patients were more likely to be diagnosed with asthma (p<.0001). No significant relationship was found between reason for referral, F_ENO, blood eosinophil count, or IgE and reactivity to either bronchial challenge.

Conclusions

Methacholine challenge identified asthma in patients prescribed asthma treatments with characteristic symptoms. Mannitol detected airway hyperreactivity in patients with reduced lung function. Additional clinical information may help in selecting appropriate challenge methods for individual patients.

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		Reactivity Group (n)			
		Non-reactive (45)	Mannitol Positive (9)	Methacholine	*P=*
Allergic / Inflammatory Markers	Blood eosinophils (g/l)	0.2 [0.175-0.4]	0.2 [0.1-0.25]	0.4 [0.1-0.3]	*NS*
	Total IgE (Ku/l)	90.0 [20.5-207.25]	116.00 [41.25-1530.25]	69.00 [38.50-161.50]	*NS*
	F_ENO (ppb)	17.0 [10.0-29.0	15.50 [8.50-24.75]	18.50 [9.50-61.75]	*NS*
Diagnosis (% of group)	Asthma confirmed	0	56	39	*p<0.0001*
	Asthma excluded	44	33	6	
	No follow-up	56	11	44	
Presenting Symptoms (% of group)	SOB	31	67	67	*p=0.013*
	Cough	24	22	78	*p<0.001*
	Wheeze	27	33	39	*NS*
	RRTI	13	11	17	*NS*
Reason for referral (% of group)	Query asthma	18	22	33	*NS*
	Asthma	18	33	39	
	Cough or bronchitis	13	11	6	
Asthma treatment (% of group)	Oral steroid	24	33	61	*p= 0.022*
	ICS	56	78	94	*p=0.009*
	SABA	38	56	78	*p=0.015*
Spirometry	*FEV_1 (% pred) (l)	97.3 [17.5]	76.9 [14.8]	89.5 [15.0]	*p=0.003*
	*FVC (% pred) (l)	107.2 [15.8]	97.9 [21.1]	102.4 [17.9]	*p=0.244*
	*FEV_1/FVC (%)	78 [69.5-80.8]	68 [60.6-75.4]	73.2 [70.0-77.3]	*p=0.029*
	*PEF (% pred) (l/m)	102.3 [19.6]	84.4 [12.3]	94.1 [19.0]	*p=0.020*

Abbreviations: SOB – Shortness of Breath; RRTI – Recurrent Respiratory Tract Infections; ICS – Inhaled Corticosteroid; SABA – Short Acting Beta Agonist; FEV_1 -(% pred) - Forced Expiratory Volume in one second as a percentage of the predicted value; FVC (% pred) – Forced Vital Capacity as a percentage of the predicted value; FEV_1/FVC – Forced Expiratory Ratio; PEF (% pred) - Peak Expiratory Flow as a percentage of the predicted value IgE – Immunoglobulin E; FENO – Fractional Exhaled Nitric Oxide

P09 - DOES SPIROMETRY ALONE CAPTURE ALL RESPIRATORY ABNORMALITIES ASSOCIATED WITH ABNORMAL LUNG FUNCTION?

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1. *Cambridge University Hospitals, Addenbrookes Hospital, Cambridge, United Kingdom*

Introduction and Objectives

Respiratory disease is the third biggest cause of death in the UK[1], and for the first time, NHS England (NHSE) has designated respiratory disease as a clinical priority. The NHSE Long Term Plan highlights earlier and more accurate diagnosis as an objective. To identify respiratory disease earlier, the plan relies on quality performance of spirometry within the primary care setting. However, lung gas exchange abnormalities can be present in lung disease despite normal spirometry[2]. Therefore, some diagnoses may be missed. Our aim was to investigate within a cohort of our patients, the proportion of those with abnormal gas exchange yet normal spirometry, and whose time to first diagnoses may be protracted due to the reliance of spirometry measurement alone.

Methods

A retrospective review of all patients attending the lung function laboratory from July 1995 - July 2018 was undertaken. Spirometry and Single Breath Gas Transfer were performed to ERS/ATS standards, with +/-1.64 standardised residual FEV_1%VC Max used to identify normal spirometry and <-1.64 standardised residual used to identify abnormal TLCOc.

Results

Of 41,480 visits, 5759 (13.9%) were identified on first presentation as having normal Spirometry, yet abnormal gas transfer, once corrected for Hb.

Within the cohort of 5759 patients, 3270 were female and 2489 male, with a median (IQR) age of 63 (24) years. TLCOc median (IQR) standardised residual -2.23 (0.86). FEV_1%VC Max median (IQR) standardised residual -0.25 (1.4).

Conclusions

We have demonstrated that a large proportion of patients referred to secondary care with symptoms suggestive of respiratory disease have normal spirometry, yet abnormal gas transfer. These results have implications when solely utilising spirometry in order to detect respiratory disease earlier and will ultimately result in a continued protraction of patient diagnosis.

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P11 - IS OVERNIGHT PULSED OXIMETRY A SUITABLE DIAGNOSTIC TEST FOR SLEEP APNOEA IN THE NATIONAL HEALTH SERVICE?

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Background

University Hospitals Plymouth National Health Service Trust (UPHNT) perform overnight pulsed oximetry in patients suspected with SA. If the test result is inconclusive then further investigation by multi-channel sleep study is carried out to confirm diagnosis. This is not recommended by the American Academy of Sleep Medicine.

Methods

Ethical approval was obtained from UPHNT and University of Plymouth before data collection. Retrospective data analysis of 68 patients within the trust who were being investigated for SA between January 2017 and January 2019. Patients performed overnight pulsed oximetry followed by a multi-channel sleep study. Test results were assessed for data quality before being statistically analysed. A paired t-test and a Bland-Altman plot were used to determine whether the oxygen-desaturation index (ODI) from overnight pulsed oximetry was in agreement with the apnoea-hypopnoea index (AHI) from multi-channel sleep studies. A Chi-square test for independence was used to determine association between the method of testing and SA severity classification.

Results

ODI determined by overnight pulsed oximetry consistently underestimated AHI determined by multi-channel sleep study. There were significant differences and poor clinical agreement between diagnostic results from the two methods of testing. 30.88% of patients with SA were misclassified as normal by overnight pulsed oximetry.

Severity classification	Number of participants (when measured by overnight pulsed oximetry)	Number of participants (when measured by multi-channel sleep study)
Normal	34 (50%)	13 (19.12%)
Mild	27 (39.71%)	26 (38.34%)
Moderate	4 (5.88%)	21 (30.88%)
Severe	3 (4.41%)	8 (11.76%)

P12 - THE OSA PATHWAY: MAKING CHANGES TO IMPROVE PATIENT FLOW.

Mr Gavin Comber[1]

1. *UHNM, Stafford, United Kingdom*

Physiological services around the country are all facing increasing numbers with decreasing resources resulting in a need to streamline services whilst maintaining patient care and standards.

As a result, the Trust OSA pathway has changed so that patients no longer have to wait to see a doctor to get the results of their diagnostics investigations. Instead, the results and histories are triaged by a sleep specialist and a decision on care made; initiate CPAP, further testing, consultant review or discharge.

A retrospective analysis of 101 patients undergoing limited sleep studies for OSA was performed to determine whether this initiative would significantly reduce patient waiting times and improve patient care. Patients were grouped depending on whether they had their results triaged or had to wait until their consultant review.

A significant difference in waiting times across all measured time frames was demonstrated with the exception of days between diagnostic being performed and being made available for review; report ready to decision – 31 days and time from diagnostic to CPAP initiation – 23 days. Of those who were triaged, 48% went straight to CPAP, 20% discharged, 6% sent for further testing and 22% to have an appointment to discuss the results. This was compared to those who had an appointment where 44% had CPAP, 39% discharged and 11% further testing.

The changes in pathway to allow for results to be triaged using patient reported history and diagnostic results significantly reduces the patients' waiting times when referred to secondary care for possible OSA. The greatest difference was seen in the time between a diagnostic report being made available and a decision being made. This offers a number of benefits to the patient by not only reducing their wait time but allowing recognition of urgent cases which can then be expedited. This also reduces stress on the service caused by changing appointment dates that the results are required for and leads to advanced roles by physiology staff in taking appropriate histories and delivering diagnoses.

	All	Appointments	Triaged	p-value Appointment vs Triaged
Number	101	36	65	
Days from diagnostic to report being ready	17.9	20.1	16.7	0.23
Days from diagnostic to decision being made	35	43.8	30.8	<0.05
Days from report being ready to decision being made	18.5	38.5	7.5	<0.001
Days from diagnostic to CPAP initiation	69.8	83.8	60.8	<0.05
Days from report being ready to CPAP initiation	53.9	66.8	45.7	<0.005

P13 - SUCCESSFUL USE OF ADAPTIVE SERVO VENTILATOR TO TREAT OPIOID INDUCED CENTRAL SLEEP APNOEA

Mrs Claire Pitcher[1]

1. *Royal Derby Hospital, Derby, United Kingdom*

51 year old presented to the sleep apnoea clinic with classic symptoms of obstructive sleep apnoea (OSA). He had been referred by his GP for excessive daytime sleepiness, Epworth sleepiness score (ESS) 19/24, he was overweight with a BMI of 29. Overnight pulse oximetry showed cyclical desaturations with an ODI of 40 and mean saturations 93%.

He had history of addiction to Oxycodone and had been on a weaning regime of Methadone which he was currently taking 105mg daily.

CPAP treatment was commenced in December 2016 with remote monitoring enabled. It soon became apparent that CPAP was not benefitting the patient symptomatically. The AHI derived from the device's algorithm was showing an obstructive index of 7 and central index of 28. Methadone use was the most likely cause of the central events.

The patient continued with CPAP treatment for three months with good compliance averaging 5.5 hours/night and continued to wean the Methadone. ESS remained high and the patient was dozing throughout the day.

It was decided at sleep MDT that he would be a good candidate for an adaptive servo-ventilator (ASV) device.

Within one month of swapping from CPAP to ASV he had noticed massive symptomatic benefit, now scoring zero on the ESS.

The patient continued using the ASV device and attended for annual follow up whilst continuing to wean the methadone.

July 2019 the patient contacted the sleep team informing us that he had completely weaned off the methadone and would like to be retested.

A limited sleep study was performed which showed the central sleep apnoea to have completely resolved. AHI 8.9, ODI 9.8, central index 0.8, obstructive index 0.2 and hypopnea index 8.3.

Patient is now trialling a month with no treatment at all to see how he feels.

Learning Points

Pulse oximetry as first line test missed the central aspect. The department is swiftly moving towards using 5 channel sleep recorders as first line of testing.

All patients with an element of central sleep apnoea trial CPAP for 3 months to see if any symptomatic benefit, so treatment wouldn't have differed if centrals were picked up initially.

Relied purely on CPAP device algorithm but to good effect.

The improvement in ODI alone highlights the improvement in results overtime.

P14 - AUDIT OF A SLEEP APNOEA SERVICE: CPAP KEEPERS VERSUS RETURNERS

TM Cunnington[1], K Hodge[1], JA Hunt[1], S Huq[1], S Madathil[1], C O'Sullivan[1], F Rauf[1], Professor Brendan Cooper[1], Dr James Stockley[1]

1. *Lung Function & Sleep, QEHB, United Kingdom*

Introduction

Given the pressures on our sleep apnoea service we performed an audit of new patients suspected of having OSAHS over a 3 month period and reviewed the difference of those who remained compliant (>4hours/night at 3 months) with CPAP and those who gave up the therapy (Returners)

Methods

Data on referrals for OSA over the 3 month period (July- October 2018) using either home oximetry (n=57) Embletta polygraphy (n=38) or both (n=9) were reviewed along with Epworth Sleepiness Score (ESS), CPAP pressure (ResMed Autoset), time on CPAP. From 107 consecutive patients, complete data were available on 104 Compliant (Keeper) and Returner patients. Appropriate Student's t-tests or Wilcoxon signed rank tests used as appropriate for parametric and non-parametric analysis respectively.

Results

104 patients had an auto-titrating CPAP trial for 1 week. 57 (54.8%) were issued with CPAP, 23 (22.1%) had trial extensions and 24 (23.0%) returned their devices after 1 week. 29/57 (50.9%) were still on CPAP at 3 months. The results between Returners and Keepers are shown in Table1;

Conclusions

There were no differences in baseline characteristics of CPAP returners and keepers in terms of ESS or mean DI although there were more mild OSA patients in the returners group. Keepers were more likely to have had a previous CPAP trial. It was not possible to predict returners from their CPAP compliance or mean pressure on Night 1 or Week 1 but their duration of CPAP use was less on Night 1. Patients who fail to use CPAP on Night 1 ultimately tended to return the device. We confirm poor CPAP compliance in mild OSA is poor and CPAP should not be attempted to save resources.

We are considering simplifying our sleep apnoea pathway to a single diagnostic sleep study followed by a single night of CPAP assessment before deciding to issue CPAP long term. We anticipate reducing the number of patient:physiologist interactions dramatically from our current model and therefore increase our capacity to diagnose and treat OSAHS.

Table 1	CPAP Returners	CPAP Keepers	Significance
Baseline ESS	12.7 (5.4)	11.6 (7.0)	NS
Baseline ODI/DI	34.6 (26.5)	34.5 (28.9)	NS
Previous CPAP trial	11/57 (19.3%)	12/24 (50%)	p<0.05
Mild/Moderate/Severe	22/16/21	5/13/15	(Mild only) p<0.05
No. Compliant at Night1	63	24	p<0.05
No. Compliant at Week1	47	57*	NS
No. Compliant at 3 Months	0	33	p<0.05
Extended trial after 1 week	24	6	p<0.05
Issued CPAP	57	33	p<0.05
Returned CPAP @ 1 week	24	0	p<0.05
Days used	7.36 (15.7)	43.4 (59.7)	p<0.05
Failed to use CPAP on Night 1	5/57 (20.8%)	5/24 (8%)	p<0.05
CPAP Pressure (cm H2O) N1	13.3 (3.9)	10.2 (4.5)	NS
CPAP Compliance (mins) N1	171 (112)	376 (145)	p<0.05
3/12 Compliance (Mild)		14.4 (9.5)	
3/12 Compliance (Moderate)		78.5 (37.2)	
3/12 Compliance (Severe)		69.4 (33.7)	

Mean and standard deviation (SD) Compliers vs Returners: significances = NS

*Patients persuaded to do 1 week trial after failing Night 1.

P15 - AUDIT OF A SLEEP APNOEA SERVICE: HOW LONG SHOULD A CPAP TRIAL LAST?

TM Cunnington[1], K Hodge[1], JA Hunt[1], S Huq[1], S Madathil[1], C O'Sullivan[1], F Rauf[1], James Stockley[1], Professor Brendan Cooper[1]

1. Qehb, QEHB, United Kingdom

Introduction

We performed an audit of our routine sleep apnoea service to compare whether 1 night, 1 week or 2 week trials of CPAP assessment produced different answers.

Methods

Data on routine consecutive referrals for OSA over the 3 month period (July- October 2018) using either home oximetry (n=57) Embletta polygraphy (n=38) or both (n=9) were reviewed along with Epworth Sleepiness Score (ESS), From 104 patients, complete DI, CPAP pressure using ResMed Autoset, and ESS data were available on 70 patients. Oximetry on CPAP was measured using oximetry and the AHI on Night 1 was taken from the CPAP itself. Student's t-tests or Wilcoxon signed rank tests were used as appropriate for parametric and non-parametric analysis respectively. Patients received an auto-titration CPAP assessment for 1 or 2 weeks and we analysed their compliance on nights1, 7 and/or 14 respectively.

Results

1 patient (1.4%) was classified as normal, 14 (20.0%) had mild, 23 (32.9%) had moderate, and 32 (45.7%) had severe OSAHS. Baseline ESS (mean (SD) was 12.8 (5.3) and by the end of all trials dropped to 8.8 (6.0), NS.

The results for ODI/DI are shown in the Table1 and show that there were no differences in the ODI/DI on night 1, week 1 or week 2.

The mean CPAP pressure (cm H_20) was the same on Night 1 [Mean (SD)13.8 (4.0)] and either at Week 1 or 2 [13.6 (3.8)]. The difference in CPAP pressures (cm H_2O) for 1 night, 1 week, 2 weeks or 1 or 2 weeks were between <2.0 in 47 patients, 2-3 in 10 patients, 3-5 in 6 patients and >6 in only 2 patients. Pressure differences between 1 night and 1 or 2 week assessments only differed by <3 cm H_2O in 57/65 (87.6%) of patients.

Conclusions

1. The ODI/DI on night 1, week 1 or week 2 can all be used to demonstrate that CPAP is effective. Therefore CPAP trials on 1 night are overall as useful as 1 and/or 2 week trials.
2. The therapeutic CPAP pressure can be determined after a single night assessment in most patients.
3. We believe that CPAP assessments can be shortened to a single night and that multiple nights are rarely beneficial in improving the CPAP pressure requirement.

Table 1 *ODI/DI*	Baseline	Night 1	Week 1	Week 2	Week 1or 2
Mean	39.1	4.7	4.0	4.3	4.0
Median	26.7	3.1	2.5	2.6	2.5
SD	31.4	4.6	4.3	5.9	4.7

Mean, median and standard deviation (SD). Significances = NS for all CPAP nights.

P17 - A CLINICAL QUALITY IMPROVEMENT PROJECT ON ADHERENCE TO CONTINUOUS POSITIVE AIRWAYS PRESSURE (CPAP) IN MILD OBSTRUCTIVE SLEEP APNOEA (OSA)

Miss Shirley Coelho[1], Mr Alain Al-Helou[1], Mrs Yasmin Khan[1], Mr Simon Wharton[1], Mr Rahul Mukherjee[1]

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Introduction

Benefits of CPAP in treating OSA are well-established. Several determinants of adherence to CPAP have been studied, including the apnoea-hypopnoea index at diagnosis (AHI), daytime sleepiness, facial anatomy and mask fit. However, study results have been inconsistent. Our own audit from our first Plan-Do-Study-Act (PDSA) cycle proved AHI to be a strong predictor[1] although due to limited follow-up arrangements prior to the advent of telemonitoring, the adherence in mild OSA patients given a trial of CPAP due to excessive daytime sleepiness characterised by an Epworth Sleepiness Score (ESS) >10 with AHI>10 or for troublesome snoring with unrefreshing sleep was not known.

Methods

We closed the audit loop of CPAP adherence (>4hours usage per night) of mild OSA patients that were given a trial of CPAP between 01 April and 31 May 2018, using telemonitoring.

Results

Out of a total of 43 patients confirmed to have mild OSA in the two months, 24 (56%) were offered a trial of CPAP – 2 declined and 4 had no data due to not being on telemonitoring. Out of the 18 patients with telemonitoring data, 8 (44%) were adherent at 30 days and 90 days. None of those who were non-adherent at 30 days were adherent at 90 days.

Conclusion

In mild OSA patients given a trial of CPAP for ESS >10 with AHI>10 or for troublesome snoring with unrefreshing sleep, at least a third are adherent to treatment. In keeping with our first PDSA cycle findings, AHI as a disease factor remains a strong determinant of CPAP adherence and as surmised, telemonitoring is giving better insight into CPAP management. Further studies are needed to ascertain (a) patient factors behind CPAP adherence and (b) feasibility of improving the cost-effectiveness of CPAP therapy by withdrawing CPAP machines from definitely non-adherent patients and reusing them to rationalise resource use.

References

1. Mukherjee D, Shilliday N, Chakraborty B, Daniels M, Mukherjee R. Clinical Audit of Adherence to Continuous Positive Airways Pressure (CPAP) in Obstructive Sleep Apnoea (OSA). Respirology 2017; 22:3, 88–278. (doi: 10.1111/resp.13207_165)

P18 - CLINICAL AUDIT: DO WE ACHIEVE THE 28 DAY TARGET FOR URGENT REFERRALS FOR SUSPECTED OSA IN DRIVERS?

Dr Adrian H Kendrick[1], Miss Michelle Cole[1]

1. *University Hospitals, Bristol, Bristol, United Kingdom*

NICE (2015) and the Sleep Apnoea Trust Association recommend that occupations, such as HGV drivers, are urgently referred for sleep assessment and subsequent management within 28 working days from referral. Our pathway is Stage 1 (S1) - triage for 2 nights pulse oximetry to consultant review, Stage 2 (S2) - S1 to commencing CPAP and Stage 3 (S3) – S2 to consultant follow-up.

We undertook an audit of how this pathway is working in relation to new referrals to our service, determining the time periods for each stage (S1, S2 and S3) of the pathway. Data on all urgent patients was collated from 2017 to 2019. The time points at each stage was determined in calendar days. Patients from each year were randomly selected and the data analysed.

46 patients were reviewed – 11 in 2017, 24 in 2018 and 11 in 2019. The median and range were obtained at each stage of the pathway and the results summarised in the figure. The median time for each year for S1 was 21, 28 and 36 days, for S2 was 0 for all three years and for S3 was 41, 89.5 and 23 days. For each year the median total time 62, 117.5 and 59 days. Over the 3 years, the median time for completion was 81 days (IQR of 51 to 254 days), and the range being 16 days to 640 days. Explanations for the extremes included requiring further investigations – limited polysomnography, patient and hospital appointment cancellations or being lost to follow-up. Only 12.7% of patient were completed within 28 days.

This audit demonstrates that we failed to meet the 28 day target in more than 80% of referrals for urgent pathway patients. The one positive was the ability to undertake a CPAP trial on the same day as the consultant review in most patients.

In the light of this audit we have completely remodelled our pathway to ensure that patients triaged as urgent are clearly identified and are prioritised through our system to achieve the 28 day target. We will re-audit in late 2020.

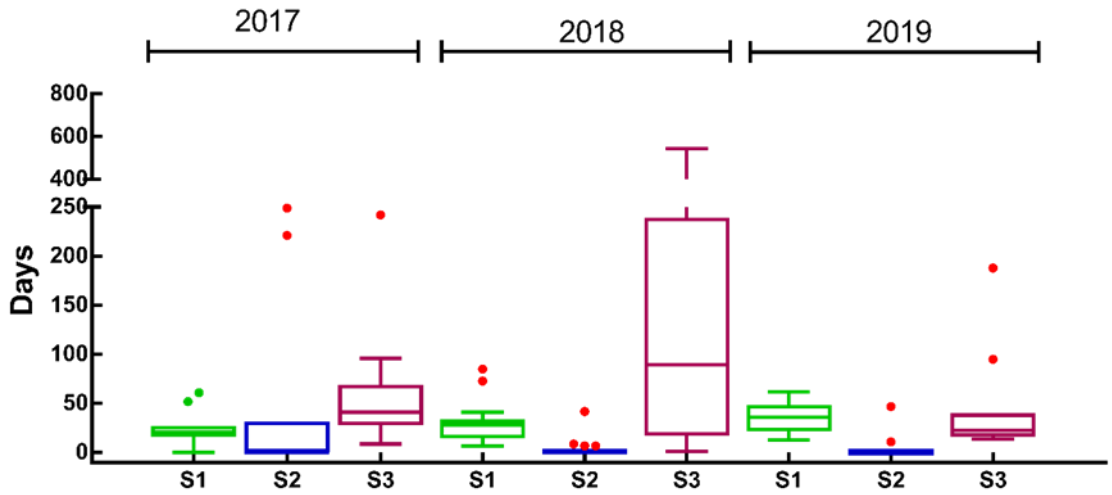

Figure. Median and IQR with outliers shown for each stage of the sleep pathway in those patients triaged as urgent across three consecutive years.

P19 - COMPARISON OF WATCHPAT TO LIMITED POLYSOMNOGRAPHY STUDIES IN ADULTS WITH SUSPECTED SLEEP-BREATHING DISORDERS.

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With the increasing drive to undertake more complex studies than simple pulse oximetry, there is a need for systems that can be easily used by patients whilst providing more information than just pulse and SpO_2. WatchPAT is a portable diagnostic device for studies of suspected Obstructive Sleep Apnoea (OSA) in adults. It is worn as a wrist pulse oximeter, but uses Peripheral Arterial Tone (PAT) to undertake complex signal analysis, thereby providing detailed information on sympathetic nervous system changes associated with Sleep Disordered Breathing (SDB) events and specific "signatures" of sleep stages.

This study had internal Trust approval and patients verbally consented to use the WatchPat device. All patients were admitted on clinical grounds for overnight sleep studies using limited (no EEG) polysomnography.

Simultaneous recordings were obtained from WatchPat and SOMNOscreen PSG (S-Med, UK). Studies were scored for SpO_2 mean, SpO_2 >4%, SpO_2 time <90% and AHI and compared using Bland-Altman analysis. Data are given mean ± SD.

39 studies were completed. The results are summarised in the table. For AHI, 25/39 (64%) of the studies were correctly classified by WatchPat as positive (mild/mod/severe) compared to SOMNO, giving a sensitivity of 75% and specificity of 80%. Of the studies that were mild (SOMNO), 10/17 (59%) were correctly identified, with 4/17 classified as normal and 3/17 as mod/severe.

This study has demonstrated that there is clinically acceptable differences between an in-laboratory study and WatchPAT for SpO_2 and AHI and therefore WatchPat could be used as an acceptable screening tool for suspected OSA. The one advantage that WatchPat provides over simple pulse oximetry is the indication of sleep versus wake and the indicated presence of REM sleep. By knowing when the patient is asleep, greater accuracy can be obtained in defining the AHI for when the patient is asleep.

Index	WatchPat	SOMNO	Bland-Altman
SpO_2 mean (%)	95.23 ± 1.06	94.4 ± 1.31	0.87 ± 1.0
SpO_2 > 4%	4.65 ± 9.34	5.5 ± 10.1	-0.85 ± 3.05
AHI (events/hr)	9.7 ± 11.9	9.6 ± 11.6	0.20 ± 7.3

Table: Summary of data comparing WatchPat to the in-lab SomnoMedics device. Data for SpO2 and AHI are from n = 39. Data are given as mean ± SD. For Bland-Altman, data is mean difference between devices ± bias of x1 SD.

P20 - BTS STANDARDS OF CARE FOR OCCUPATIONAL ASTHMA

Maximillian Thomas[1], Miss Hannah Norman[1], Professor Sherwood Burge[2], Dr Gareth Walters[2], Dr Alastair Robertson[2], Dr Vicky Moore[2]

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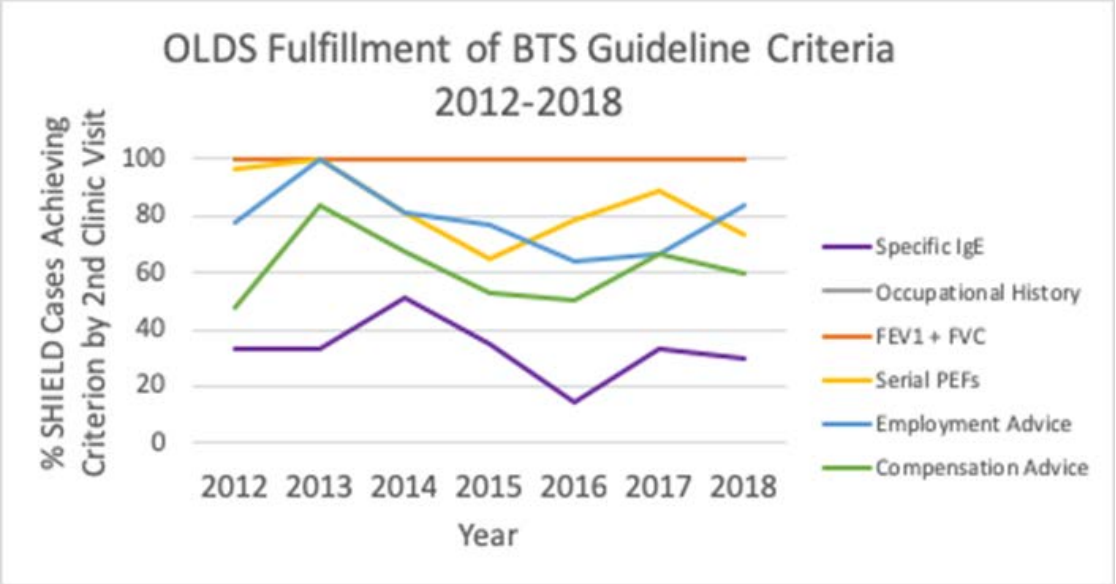
Occupational asthma (OA) is variable airways obstruction caused by exposure to an inhaled agent in the workplace. Swift detection and management of OA improves prognosis. The BTS Standards of Care for Occupational Asthma (2008) recommends that all patients with suspected OA should receive a full occupational history, spirometry for FEV_1/FVC, serial PEFs, specific IgE bloods, employment advice and compensation advice by their second outpatient appointment. We compared the Birmingham Occupational Lung Disease Service's (OLDS) adherence to the BTS Standards of Care for OA to highlight areas of the service requiring improvement. The Midlands Thoracic Society surveillance scheme database of all Regional OA patients (known as Shield), was utilised to identify all workers notified with OA between 2012 and 2018 (n=146).

Results

A comprehensive occupational history and spirometry were carried out in all patients. The completion of serial PEF recording and Oasys analysis (the principal method of objective confirmation of occupational asthma) dipped to 63% in 2015, exacerbated by referral after removal from employment. Provision of compensation and employment advice was lower at the time of notification, as employment advice requires the identification of the cause of occupational asthma, which often took longer. Specific IgE measurement was the lowest as not generally available for most agents. The OLDS performed the best in 2013, with 86% fulfilment of the guidelines. There was a subsequent steady decline to 67% in 2016 when the service was without a lead. Since appointment of a service lead, performance has improved (See Figure).

Recommendations for service improvement include the production of an instructional video for ideal PEF technique, text reminders for patients to record PEF data, and investment into smartphone-compatible digital PEF meters for easy recording and sharing of data. Computer alerts for clinicians reminding them to complete and record fulfilment of BTS criteria as well as the production of local standards of care may improve service provision for the future.



P22 - THE EFFECTS OF SINGLE BREATH GAS TRANSFER MEASUREMENTS ON CARBOXYHEMOGLOBIN LEVELS OVER THE PERIOD OF A WORKING DAY.

Miss Ella O'Neill[1], Mr Matthew Rutter[1], Dr Karl Sylvester[1]

1. *Cambridge University Hospitals, Cambridge, United Kingdom*

Background:

There is minimal research on the effects of high -intensity short time exposure of carbon monoxide. The impact of performing single breath gas transfer as part of the biological control process on carboxyhaemoglobin (COHb) levels throughout the day should first be studied to enable justification of researching the potential long-term effects it can have on the participant.

Methods

Using a Micro+ Smokerlyser (Bedfont Scientific Limited, 2009), parts per million (ppm) of exhaled carbon monoxide was measured and an estimation of COHb in percent provided. Four male, and one female physiologist mean (SD) age 28±9.8 years took part in the study. COHb was measured at baseline and immediately post two standard single breath gas transfer procedures with four minute intervals between. Further COHb measurements were made every 30 minutes for the first 2 hours, followed by every hour from 2-7hours.

Results: See Figure

Conclusions

There are considerably raised COHb levels post single breath gas transfer measurements at levels similar to the World Health Organization (2010) carbon monoxide limits. Levels remain within the light smoker range at least 7 hours post procedure. Further research is warranted into the potential long term health effects of participants partaking in biological quality control procedures that incorporate single breath gas transfer measurements on a high frequency basis. The latest ATS/ERS (2017) recommendations for the validation of gas transfer suggest biological quality controls be performed weekly. This can be from a healthy participant or mechanical syringe. The long term effects of biological quality control of gas transfer have yet to be studied but with this research and latest recommendations, it may encourage and inform departments to look into other methods of validation.

Graham BL, Brusasco V, Burgos F, et al. 2017 ERS/ATS standards for single-breath carbon monoxide uptake in the lung. Eur Respir J 2017; 49: 1600016 [https://doi.org/10.1183/ 13993003.00016-2016].

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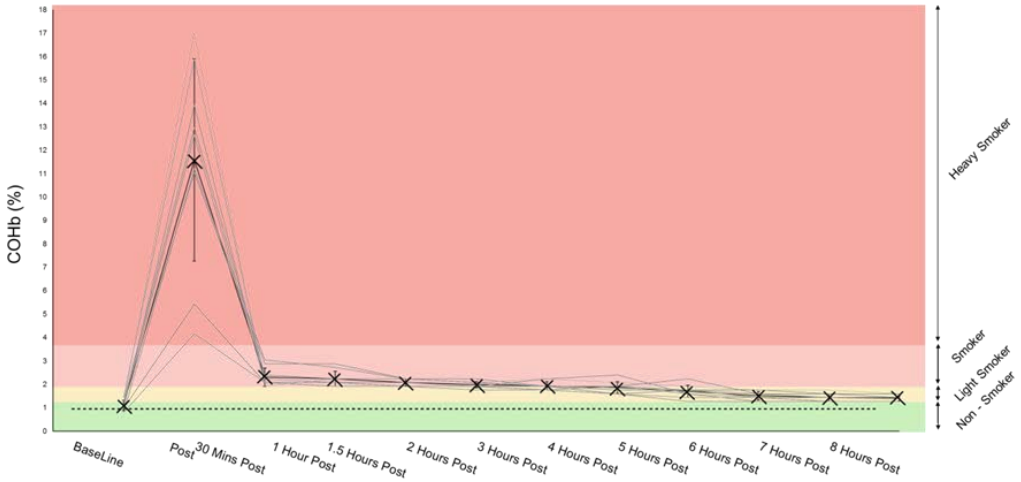


Figure 1: Solid black line indicates the mean data for all participants and grey lines demonstrate individuals data. Changes in COHb levels immediately post gas transfer measurement are demonstrated, followed by a rapid decline in COHb during the first half hour post gas transfer. Base line results showing mean(SD) 1.08±0.22 COHb%, 11.57±4.32 COHb % directly post and 1.39±0.12 COHb% 8 hours post gas transfer testing.

P23 - ARE WE USING THE RIGHT PARAMETERS TO GRADE A RESTRICTIVE VENTILATORY DEFECT?

Miss Joanna Hull[1], Mrs Jill Macleod[1]

1. *NHS Lothian, Edinburgh, United Kingdom*

Introduction

The ATS/ERS guidelines (2005) define a restrictive ventilatory defect as a reduction in total lung capacity (TLC) below the 5th percentile of the predicted value with a normal FEV/VC ratio. The gold standard of diagnosis involves measuring TLC through static lung volume (SLV) testing.

Historically static lung volumes have been used to confirm a diagnosis of pulmonary restriction however with recent advances through drug trials, medication and increasing demands on services, the primary focus has concentrated on monitoring changes in ventilatory capacity (VC).

Aim

To evaluate the importance of TLC measurement in monitoring a restrictive ventilatory defect as opposed to measuring VC alone.

Method

An audit was carried out within the respiratory physiology service at the Royal Infirmary of Edinburgh within a four month period to investigate how a potential diagnosis would differ if patients attended solely for spirometry and transfer factor rather than full pulmonary function tests (spirometry, transfer factor and lung volumes – He dilution) as part of their routine review. The patient group focused mainly on those who had referral querying a restrictive ventilatory defect for example, pulmonary fibrosis, asbestosis, interstitial lung disease.

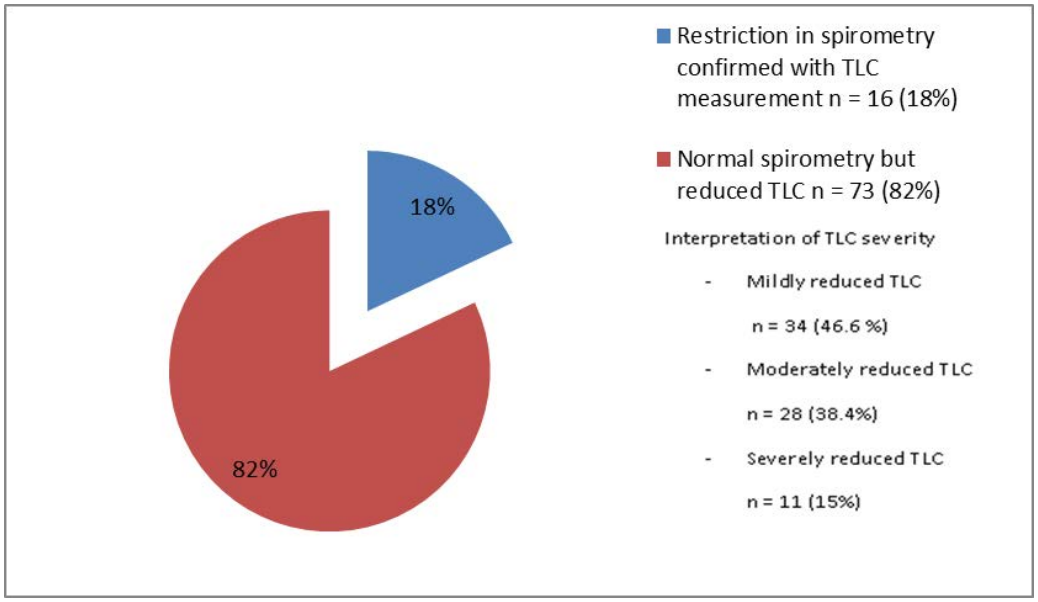
Results: See Figure below

Conclusion

73/89 patients had normal spirometry so without lung volume measurement a likely diagnosis of true restriction would not have been made, potentially resulting in misdiagnosis and limiting access to treatment options.

Reference

ATS/ERS task force: Standardisation of lung function testing. Interpretative strategies for lung function tests. Eur Respir J 2005;26:948-968



P24 - PRE-OPERATIVE SPIROMETRY IDENTIFIES UNDIAGNOSED LUNG DISEASE IN CARDIAC PATIENTS

Mr Sam Town[1], Mr Rob Peat[1], Mrs Dot Price[1], Dr Freddy Frost[1], Dr Dennis Wat[1]

1. *Liverpool Heart and Chest Hospital, Liverpool, United Kingdom*

Background

In the UK around 1.2million people have a formal diagnosis of COPD, however, over 2 million more may be undiagnosed. Shared risk factors and symptoms exist for cardiovascular disease and COPD. Many cardiac surgery candidates undergo spirometry for pre-operative assessment; this may represent a potential case-finding opportunity. We aimed to assess the utility of pre-operative spirometry to identify undiagnosed lung disease in patients listed for cardiac surgery.

Methods

100 consecutive patients performed pre-cardiac surgery spirometry according to ATS/ERS guidelines. Obstruction was defined as FEV_1/FVC <0.7. Reversibility was not performed and no distinction between COPD, asthma, and lung diseases was made after testing. A detailed search of patient's hospital electronic patient record system was performed after patient discharge.

Results

Of the 100 patients undergoing cardiac surgery a total of 43 patients (43%) had airflow obstruction, 42 (42%) were normal, and 15 (15%) were restrictive.

Of the obstructive patients 14 (33%) were mild, 25 (58%) moderate, and 4 (9%) were severe. Pre-existing lung disease or abnormality was documented in 18 (42%) obstructive patients. COPD was reported in 12 (67%), asthma in 4 (22%), bronchiectasis in 1 and 'obstructive lung function' in 1. Medications prescribed for lung conditions were documented for 14 (33%) patients. Reference to spirometry was shared with a GP in 13 (30%) patients. Of the 13 incidences where some spirometry information was shared, all main spirometric indices (FEV_1, FVC, FEV_1/FVC ratio) or an interpretation of spirometry were only provided on 1 occasion.

Conclusion

A high proportion of patients undergoing cardiac surgery had airflow obstruction, many with no prior diagnosis of respiratory disease. Spirometric findings were poorly disseminated resulting in under-diagnosis in those without established respiratory disease or potential test duplication. The routine sharing of pre-operative spirometry may reduce missed cases of disease and reduce test duplication. Furthermore, the opportunity to optimise previously undiagnosed lung disease to improve surgical outcomes warrants further investigation.

P25 - MODIFIED CO UPTAKE AND ELIMINATION MODEL COMPARED WITH PULMONARY FUNCTION OBSERVATIONS

Miss KE-TING PAN[1], Professor Giovanni Leonardi[2,3], Mr Mark Unstead[4], Dr. Shih-En Tang[5,6], Professor Kun-Lun Huang[5,6], Professor Ben Croxford[1]

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2. *Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Didcot, United Kingdom*
3. *London School of Hygiene and Tropical Medicine London, London, United Kingdom*
4. *Royal Berkshire Hospital, Berkshire, United Kingdom*
5. *Department of Internal Medicine, Tri-Service General Hospital, Taipei, Taiwan (ROC)*
6. *Institute of Undersea and Hyperbaric Medicine, National Defence Medical Centre, Taipei, Taiwan (ROC)*

Introduction

Carbon monoxide (CO) poisoning is an important public health issue globally. Mathematical models for predicting the uptake, distribution, and elimination of CO could help assess exposure scenarios. The best-known models are the Coburn-Foster-Kane (CFK) equation and the Bruce and Bruce multi-compartment model. Both produce acceptable predictions when compared with observations. However, several additional factors could improve the model, such as including variations with height, age, smoking, lung function and disease status.

Purpose

We aim to investigate a simplified version of the compartment model for CO by comparing its predictions against observed data.

Method

As CO is routinely used to estimate lung function, observed data gathered from lung function testing can be used to estimate variations in model predictions. We collected 3,512 patients' data from June 2017 to May 2018 from Tri-Service General Hospital (TSGH) in Taipei. After excluding the data not fulfilled the study criteria, there were 419 patients analysed demographic variables and CO diffusion capacity (DL_{CO}) from TSGH. This study has obtained the ethics committee approval from TSGH and UCL.

Results

The predicted model for DL_{CO}(TL_{CO}): Women= -3.856-0.119*age(yr)+0.133*height(cm)+0.125*weight(kg); Men=-1.321-0.210*age(yr)+0.165*height(cm) +0.102*weight(kg).

Then, the researchers used the model from Gosselin et al. to predict the effects of different variables (Figure 1). We calculated the DL_{CO} and VA from the predicted model in the study by assuming man (case a1): 20 yrs, 180 cm and 75 kg; woman (case b1): 20 yrs, 160 cm and 50 kg. The DL_{CO} were 31.829 ml/mmHg/min (TL_{CO}: 10.656 mmol/min/kPa) for man and 21.294 ml/mmHg/min (TL_{CO}: 7.129 mmol/min/kPa) for woman. After reviewing against the lung function data, the researchers modified the values of DL_{CO} to 40 ml/mmHg/min (TL_{CO}: 13.392 mmol/min/kPa) for man (case a2) and woman (case b2) to see the influence of the change.

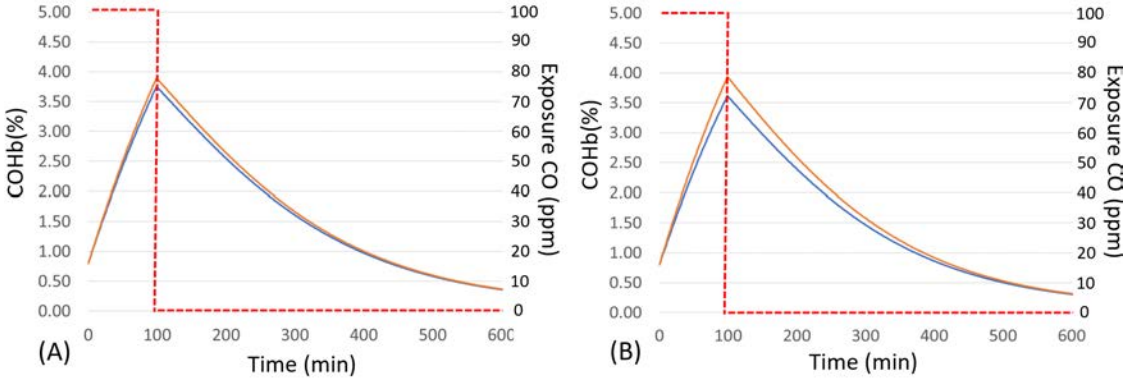

Figure 1. Simulation of CO uptake and elimination model. (A) predicted CO model for man (B) predicted CO model for woman. #Blue line predicted CO model for cases a1 and a2; Orange line predicted models when DL_{CO} changed to 40 ml/mmHg/min.

P26 - AUDIT OF INACCURATE REFERRALS FOR LUNG FUNCTION TESTING

Miss Shirley Coelho[1], Mrs Vicky Moore[1], Mr Gareth Walters[1]

1. *University Hospitals Birmingham, Bordesley Green, United Kingdom*

Background

As part of Improved Quality in Physiological Services (IQIPS) accreditation, we developed monthly drives in order to tackle specific tasks. One of these was based around identifying inaccurate requests that may not answer the clinical question posed and lead to unnecessary visits.

Aim

To assess the frequency, reason and source of inaccurate lung function referrals.

Method

Throughout the month of July 2019, all lung function referrals made to Heartlands Hospital were scrutinised by one member of staff. For each request we collected data on: in or out patient request, requesting individual, consultant's authority, the speciality, reason for testing, tests requested and the corrections made. A referral was deemed inaccurate if 1) a bronchial reactivity test was requested and no treatment form completed; 2) there was no clinical information or 3) the wrong tests were requested based on the clinical question.

Results

In July 2019, our department received 206 requests for lung function. Respiratory is the main referrer with 72% (147) of referrals, followed by haematology with 10% (21). 25% (52) were deemed inaccurate; 67% (35) of which were due lack of treatment form, 12% (6) due to lack of clinical information, 17% (9) due to wrong tests requested and 4% (2) due to "other" reasons. The Figure below represents the inaccuracies per speciality.

Conclusion

We were expecting a higher number of inaccurate referrals; this might be due to the time frame chosen to collect data. The main issue of non-completion of the treatment request form should be solved once the requests and prescription can be done electronically. The number of "wrong tests" requested could be due to changes in guidance or limited knowledge of what tests are needed for specific procedures. We were expecting more requests from Rheumatology, given the tight link between rheumatologic conditions and treatments and lung damage.

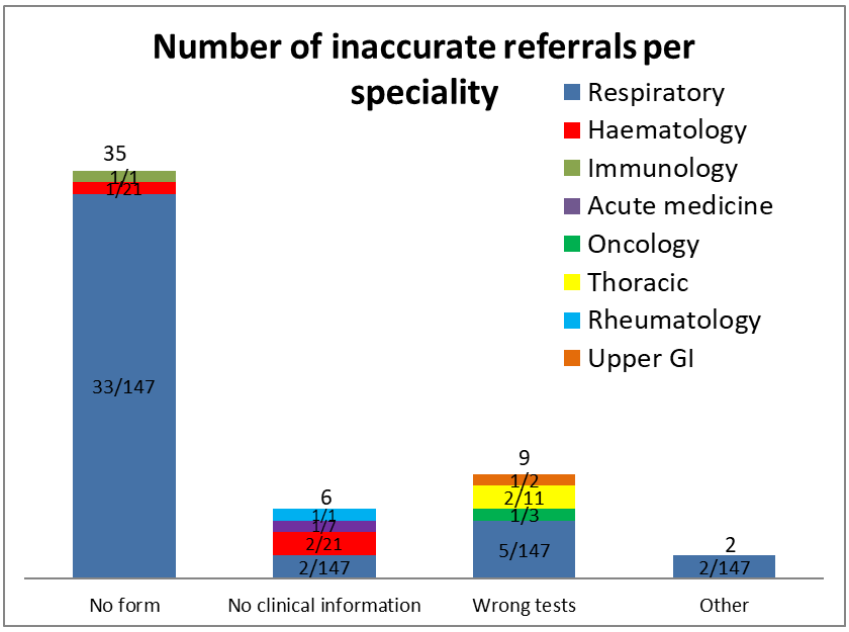

Figure 1 - % of inaccurate requests per specialty. The number of inaccurate requests is against the total referrals made by specialities.

P27 - CARDIOPULMONARY RESPONSE TO STAIR CLIMBING IN PATIENTS WITH DYSFUNCTIONAL BREATHING: AN EXAGGERATED FIGHT OR FLIGHT RESPONSE?

BSc Karina Siewers[1], MD, PhD Emil Schwarz Walsted[1,2], BSc Bishman Manivannan[2], Mr Christopher Warren[2], Dr Colm McCabe[2], Dr James H Hull[2]

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2. *Department of Respiratory Medicine, Royal Brompton and Harefield NHS Foundation Trust, London , UK*

Background

Dysfunctional breathing (DB) is recognised to be a prevalent cause of unexplained exertional dyspnoea[1]. Anecdotally, many patients with DB report breathing difficulty on commencing stair walking. A disordered ventilatory response has previously been proven in DB during cardiopulmonary exercise testing (CPET) in a laboratory setting[2]. The aim of this work was to now evaluate the ventilatory response to a real-life stair climb protocol, in patients with DB and compared with a matched control group.

Methods

A prospective cohort study of adults with DB were recruited from our unexplained breathlessness service. Participants were required to complete dyspnoea-related questionnaires (Dyspnoea-12 and a Nijmegen), spirometry and a stair-climb challenge (4 flights) with portable CPET equipment in situ. Dyspnoea on the BORG scale (0-10) was measured at rest and on stair climb cessation. Age, gender and BMI matched controls were recruited to undergo similar assessment. Data were analysed using Mann-Whitney U test comparing controls and DB subjects and P-values of < 0.05 were considered significant.

Results

We assessed 11 subjects with DB and 13 controls, well matched for gender and age (Table). Patients exhibited higher questionnaire scores and had evidence of an amplified ventilatory response to the stair challenge. Specifically, peak values and change in ventilation and breathing frequency was greater in patients, despite normal resting lung function and a similar peak oxygen uptake and heart rate response.

Conclusion: Patients with DB demonstrate an exaggerated ventilatory response to stair climbing. Specifically, perception of dyspnoea and change in ventilation is greater despite a matched cardiac response, when compared with a control group. This finding aligns with patient's self report and provides insight regarding the control of ventilation to real-life activity in DB. Further work is now needed to explore underlying mechanisms for this disordered physiologic response.

1. Boulding R, et al. Eur Respir Rev. 2016;25 (141):287-294. doi:10.1183/16000617.0088-2015
2. Bansal T, et al. Respir Physiol Neurobiol. 2018;255:1-6. doi:10.1016/j.resp.2018.05.002

	Control (N = 13)	Patient (N = 11)	p value	
Gender: M:F	3:10	5:6		
Age	49 (8.0)	54 (9.9)	0.19	
BMI	25.8 (5.2)	28.7 (2.9)	0.05	*
FEV1% predicted	99 (15.8)	109 (10.3)	0.23	
FVC% predicted	101 (17.8)	115 (12.3)	0.04	*
FEV1/FVC Ratio	0.82 (0.0)	0.78 (0.1)	0.04	*
Nijmegen	3.5 (4.7)	23.1 (9.8)	0.00	**
Dyspnoea-12	0.0 (0)	15.7 (8.6)	0.00	**
REST MEASUREMENTS:				
VE rest (L/min)	11 (4.1)	12 (4.9)	0.36	
BF rest (1/min)	17 (3.3)	22 (5.0)	0.01	*
VO_2 rest (ml/min/kg)	4.5 (1.2)	3.8 (0.7)	0.11	
HR rest (1/min)	78 (14.3)	78 (9.5)	0.73	
Borg Rest	0.1 (0.3)	0.6 (0.8)	0.06	
PEAK MEASUREMENTS:				
VE peak (L/min)	24 (8.6)	36 (9.0)	0.01	**
VE % of Max (%)	22 (0.1)	31 (0.1)	0.02	*
BF peak (1/min)	21 (4.1)	31 (11.0)	0.00	**
VO_2 peak (ml/min/kg)	13.2 (2.6)	14.1 (3.0)	0.57	
HR peak (1/min)	121 (18.9)	116 (16.8)	0.65	
Borg Peak	0.8 (0.8)	4.3 (1.6)	0.00	**
CHANGE FROM REST TO PEAK:				
ΔVE (L/min)	13 (6.7)	23.6 (5.4)	0.00	**
VE change (%)	125 (73.7)	206 (52.3)	0.01	**
ΔBF (1/min)	4 (4.2)	10 (8.6)	0.21	
BF change (%)	27 (29.4)	45 (39.7)	0.42	
VO_2/kg % change	209 (114.0)	275 (74.5)	0.04	*
ΔVO_2 (ml/min/kg)	8.6 (2.8)	10.3 (2.7)	0.23	
ΔHR (1/min)	43 (14.8)	38 (16.5)	0.61	
ΔBorg	0.8 (0.6)	3.7 (1.6)	0.00	**

Numbers are mean (SD) unless otherwise stated. **M:F**: Male:Female; **BMI:** body mass index; **FEV1:** forced expiratory volume in the first second; **FVC;** forced vital capacity; **VE:** exhaled volume/ breath; **BF:** breathing frequency; **VO_2:** Oxygen consumption/min; **HR:** heart rate: **Δ:** delta, * $p < 0.05$, ** $p < 0.01$

P28 - ESTIMATION OF THE VO2/WR SLOPE IN RELATION TO DURATION OF A TREADMILL EXERCISE TEST

Mrs Carla Thomson[1], Miss Tasmin Sharley[1], Mr Mark Hardyman[1], Mr Cal McLean[1], Dr Adrian H Kendrick[1]

1. *University Hospitals, Bristol, Bristol, United Kingdom*

Work efficiency is a measure of the metabolic cost of performing external work. In incremental exercise this is usually expressed as the slope of the relationship of oxygen uptake to work rate (VO_2/WR). This slope has a normal range of 10.3 ± 1.0 mL.min-1, or 8.3 to 12.3 at ± 2SD. We have observed that during incremental treadmill exercise, spuriously odd values are observed.

WR from the treadmill was estimated based on the speed, slope and weight of the subject. A modified Balke protocol was used with speed adjusted to the capability of the subject with 3% increments every minute. VO_2 was directly measured via a facemask. All data was presented within an integrated CPET system (LoveMedical, UK). Each slope was visually assessed to ensure accuracy.

Data on 99 patients were collated for the duration of exercise and the VO_2/WR slope. 41 were referred from the congenital heart group, 53 from Pre-Op and 5 from other sources. The median (IQR) duration of exercise was 7.1 (5.4 – 10.0) mins and VO_2/WR slope was 8.5 (6.0 – 11.2). There was a curvilinear relationship between VO_2/WR and duration of exercise (figure), with significantly high values observed during short period of incremental exercise and more stable values above 6 minutes of exercise. There was no obvious differences between the two groups.

The importance of an ideal minimum of 6 minutes of exercise is demonstrated in this study, where there appears to be insufficient time to accurately derive the VO_2/WR slope. Greater than 6 minutes appears to be have little effect on the accuracy of the estimation of the slope during treadmill exercise.

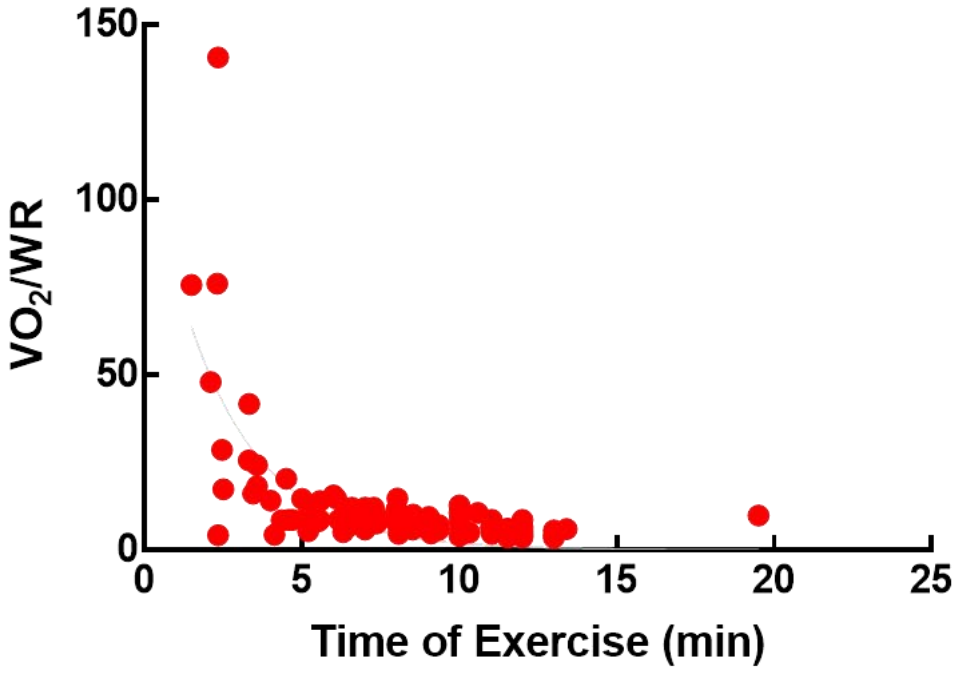

Figure. Relationship between VO_2/WR and time of exercise using a modified Balke protocol on a treadmill. The relationship is approximately described as $Y = 118.1^{e(-0.4135X)}$

P29 - CARRYOVER EFFECTS OF SPIROMETRY AND BRONCHODILATOR ON MEASURED FENO VALUES IN CHILDREN

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1. *Royal London Hospital, , United Kingdom*

Background/Intro

Guidelines recommend measurement of fractional exhaled nitric oxide (F_eNO) before spirometry to avoid distortion of results by forced expiratory manoeuvres. Existing studies give conflicting results.

Objective

To assess the impact of spirometric procedures on F_eNO in children

Methods

20 patients aged 6-17 years underwent F_eNO measurement using the 6 second exhalation modes at baseline, 1 minute post-spirometry and 15 mins post-subsequent bronchodilator (BD) administration (400mcg of salbutamol delivered via MDI and spacer). Patient characteristics were (Mean±SD); Age 12.2±3 years, Height 151±17cm, Weight, 55±26kg, FEV_1% of predicted 93±16%, and FVC% of predicted 103±12%.

Results

ATS/ERS guidelines stipulate 10% F_eNO reproducibility for a valid test. In this series, F_eNO values were: Baseline – 36 ± 23 ppb, post-Spirometry – 33 ± 20 ppb and post-BD – 36 ± 22 ppb. The percentage differences in F_eNO values at each time point were: baseline and post-spirometry - 8.4%, baseline and post-BD - 1.8% and post-spirometry and post-BD – 6.7%. There were no significant differences between all three time points (p=.059, Repeated Measures ANOVA).

Conclusion

Mean F_eNO at all time points was within 10% as per recommendations. We found no evidence of an effect of forced spirometry or BD administration on F_eNO in children. It may not be necessary to measure F_eNO before spirometry.

P30 - TOOLS FOR SLEEP APNOEA MANAGEMENT: A CASE REPORT OF POST-APAP CENTRAL APNOEA

Dr. Heather Engleman[1], Ms. Neena Derashri[1], Ms. Sara Stevens[1], Mr. Nuno Faria Cachada[1], Ms. Sarah Martin[1], Ms. Lauren Creswick[1], Mr. Tom Kelly[1], Dr. Prasanna Sankaran[2]

1. *Philips UKI, Chichester, United Kingdom*
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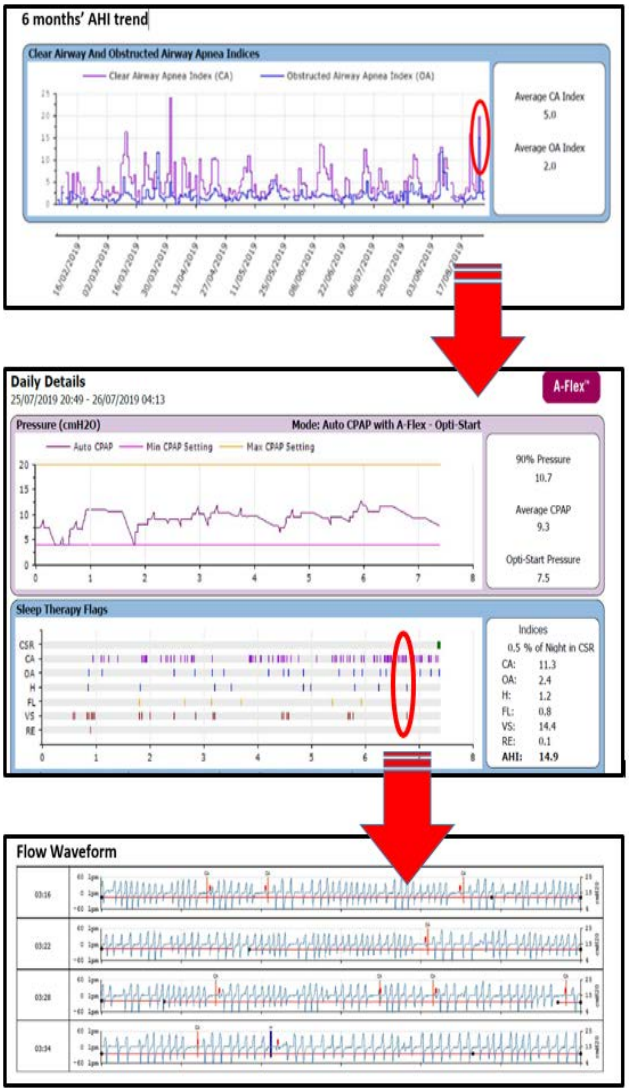
Mr. AB, a 62 year-old man, was assessed at Norfolk and Norwich Hospital's Sleep Clinic. Mr. AB was referred for excessive daytime sleepiness and snoring, with a home cardio-respiratory sleep study showing an apnoea+hypopnoea index (AHI) of 36/hr with 90% obstructive events. Medications reported were inhaled therapy for COPD, an oral anti-psychotic and an anti-depressant. He was diagnosed with obstructive sleep apnoea syndrome and prescribed auto-adjusting positive airway pressure (APAP) therapy. His care pathway including periodic remote monitoring via device modem and specialist reporting of objective profiles of therapy in collaboration with Philips sleep support service.

Initially poor, unstable mask fit was detected and resolved in the first week, with APAP used thereafter on 98% nights for an average 9.7 hrs/night. During periodic APAP data reviews, residual AHI was mildly raised at 7-10 per hour, with 50% clear airway (central) apnoeas. Cheyne-Stokes respiration was not detected. Echocardiogram showed no cardiac abnormality. To assess further the residual sleep-disordered breathing (SDB), summary and daily detailed therapy graphs were inspected, as well as breath-by-breath flow waveforms.

Summary trend graphs showed semi-regular peaks in residual central apnoeas. Detailed hour-by-hour graphs from peak nights showed little snoring during central apnoeas, and associated waveforms showed qualitative pattern typical of Biot's (opiate) breathing (Figure).

A telephone consultation with patient confirmed that in addition to the previously noted medications, he is also prescribed a transdermal buprenorphine patch for chronic hip pain. We speculate that central apnoea peaks may be associated with replacement of the buprenorphine patch. This case shows the value of remote monitoring to not only detect and intervene promptly in early mask leaks, but also to assess type and frequency of residual respiratory events through data inspections at different levels of granularity.



P31 - A REVIEW OF CARDIOPULMONARY SLEEP STUDIES IN NOONAN SYNDROME

Mr Aidan Laverty[1], Ms Kylie Russo[1], Dr Elaine Chan[1], Dr Martin Samuels[1]

1. *Great Ormond Street Hospital For Children NHS Foundation Trust, London, United Kingdom*

Introduction

Noonan syndrome (NS) is a genetic disorder present in 1 in 2500 live births in the UK. It is characterised by facial deformities, short stature, cardiac defects and chest deformity. The additional presence of a small jaw and large adenoids may lead to obstructive sleep disordered breathing (oSDB) in children, but there are little data available on the incidence and prevalence of SDB or hypoventilation in children. We reviewed the cardiorespiratory sleep recordings performed on children with Noonan syndrome.

Methods

A retrospective review of cardiorespiratory sleep recordings performed on patients with Noonan syndrome (using Embla S4500 and Radiometer TOSCA500/TCM5) between Jun 2009 and Mar 2019. Studies were analysed according to AASM criteria.

Results

Over 10 years, we performed 34 studies on 14 patients; 6 patients had >1 study. Median age was 140 months (IQR=93-181), 8 male. Three patients had chronic lung disease, 3 had pulmonary hypertension and 2 associated Arnold Chiari malformation. Median total AHI (1.2 evs/hr) indicated mild sleep disordered breathing (oAHI=0.6, CnAHI=1.0) and normal transcutaneous CO_2. One patient displayed severe obstructive sleep disordered breathing with hypoventilation. Two patients had received adenotonsillectomy, 1 patient had a tracheostomy in situ, 2 patients received non-invasive ventilation (NIV) and 5 used supplemental O_2 during the studies.

Table 1 – sleep study data Parameter	Units	Median
Active Sleep	%	29
SpO_2	%	95.2
SpO_2 ODI	Dips/hr	4.5
SpO_2 mean nadir %	%	92.4
TST SpO_2<90%	%	0.01
SpO_2 nadir	%	90
AHI	Evs/hr	1.2
$TcCO_2$	mmHg	39
$TcCO_2$ max	mmHg	42

P32 - DIFFERENCES IN HEIGHT PREDICTION BETWEEN ULNA LENGTH, ARM SPAN AND STANDING HEIGHT IN PAEDIATRICS.

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1. *Children's Hospital Evelina London, Westminster Bridge Road, United Kingdom*

Abstract

Background

Arm span, ulna length and standing height were measured in 30 patients aged 5 – 18 years who were not all free from physical deformities which can affect stature or arm span

.

Introduction

Height measurement is important for assessment of children's growth, prediction and standardisation of physiological parameters including lung volumes, spirometry, transfer factor, muscle strength and according to World Health Organisation (1995), adjustment of drug dosage in patients. It is hard to measure body composition with accuracy due to influence by nutritional status and genetic factors.

Methods

The service evaluation was conducted by paediatric respiratory medicine department at Evelina London Children's Hospital, Westminster, London. Patients aged 5 to 18 years were recruited (with consent) for this study with asthmatic/neuromuscular condition. A paediatric respiratory physiologist collected the data for standing height, arm span and ulna length from all the patients.

Results

Measurements were analysed using one-way repeated measures analysis of variance tests (SPSS 25.0). The findings of the current service evaluation show no significant different between standing height, arm span and ulna height (p= 0.385).

Conclusions

No significant difference were found between the three measurements taken. Future studies could look to increase the number of patients

P33 - HYPOXIC CHALLENGE TESTING IN INFANTS; WHO IS RECOMMENDED TO FLY WITH SUPPLEMENTAL OXYGEN?

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Background

Infants with a history of neonatal chronic respiratory problems may demonstrate hypoxaemia when at in-flight oxygen levels, despite normal sea-level oxygen requirements[1]. BTS recommend these infants have hypoxic challenge testing (HCT) before air travel, SpO_2 <85% is recommended as a threshold below which in-flight oxygen is required and "*paediatrician discretion should be used when SpO_2 between 85-90% and, where there is doubt, the doctor should err on the side of caution*." [1]

Aims

To establish how many infants fell into each of the threshold categories during HCT; SpO_2 <85%, >90%, 85-90% and which of these patients were recommended to fly +/- supplemental oxygen (suppO2).

Methods

Our HCT protocol for infants is 20 minutes in 15% FiO_2 within a body plethysmograph. SpO_2 is monitored throughout and suppO2 administered via nasal cannula if SpO_2 < 85%. If at the end of 20 minutes SpO_2 has remained >85% but <90% then suppO2 is titrated for 5 minutes to provide additional information. We reviewed data collected from infants (aged < 1 year) whom had HCT between March 2017 and August 2019.

Results

Data collected from 58 infants, median age 27.6 weeks (range 5 to 51.6), 35 (60%) were male. None were receiving suppO2 in room air prior to testing; all had baseline SpO_2 ≥96%. In 36 infants, SpO_2 did not dip to <90%. SpO_2 dropped to <85% in 13 infants, requiring administration of suppO2. Nine infants required extended protocol due to SpO2 at 85-90%. SuppO2 corrected SpO_2 in all to baseline levels.

Of these 9 infants; 7 were ex-preterm, 1 recent thymus transplant, 1 pulmonary hypertension with congenital diaphragmatic hernia. 8/9 infants had a decision regarding flying post HCT. All 8 were advised by their clinician to use suppO2 for air travel. The flight times in this subgroup ranged from 90 to 450 minutes. The remaining subject that had not received guidance for air travel is an international inpatient at the hospital with no discharge date set.

Conclusion:

Infants with baseline SpO_2 ≥96% may still exhibit SpO_2 desaturation during HCT. We found all paediatricians recommended in-flight oxygen for infants with HCT SpO_2 <90%. In the SpO_2=85-90% group, flight duration did not appear to affect the recommendation made.

1. Managing passengers with respiratory disease planning air travel: British Thoracic Society Recommendations Thorax September 2011.

P34 - A COMPARISON OF SLEEP PARAMETERS MEASURED BY LIMITED MULTICHANNEL POLYSOMNOGRAPHY AND FULL POLYSOMNOGRAPHY.

Miss Demi Callis[1], Mr Liam O'Reilly[1], Miss Michelle Goodlad[1]

1. *UHCW NHS Trust , Coventry, United Kingdom*

Introduction

Inpatient full polysomnography (PSG) is the gold standard diagnostic to identify obstructive sleep apnoea syndrome (OSAS)[1]. Due to healthcare resources and utilisation many sleep centres employ limited multichannel sleep testing (MC) at the patient's home. Both diagnostic tests provide measurements of oxygen desaturation index (ODI), apnoea-hypopnoea index (AHI) and oxygen saturation (SpO_2). The sleep studies however are subject to factors that may influence sleep quality, including environmental effects (location of performance and staff versus patient setup) that may influence overall sleep study scoring.

Methods

All patients referred to the CSU for investigation of OSAS who subsequently performed a PSG were included in this observational study. Patients who were symptomatic (Epworth score 11) and received a diagnosis of mild OSAS (AHI 5-14/hr) continued to PSG. MC were performed using NOX T3 and PSG using NOX A1 (Nox Medical, Katrínartún, Iceland). Sleep scoring was in accordance with AASM guidelines version 2.3. Comparisons of data sets was performed using SPSS statistical software.

Results

Patient demographics are shown in Table 1. In total 8 patients were included. All patients scored a higher AHI on PSG compared to MC. Mean PSG AHI and ODI were significantly higher than MC (18.48/hr; 8.1/hr and 17.68/hr; 7.08/hr, p=<0.001 respectively). SpO_2 was comparable between PSG and MC (92% and 94%, p=0.0135, respectively).

Discussion

Data from this single centre, small sample study shows higher AHI and ODI from PSG compared to MC in symptomatic mild OSAS patients. Reasons may include location of sleep and clinical support with sleep study setup. In this patient group it may be advised that PSG is required in order to confirm a diagnosis of OSAS and severity in order to select the most appropriate treatment modality and optimisation of treatment selections. Larger multicentre studies are required to substantiate the results from this study.

n=8	Mean (sd)
Sex (m)	6
Age (years)	38 (12)
BMI (kg/m^2)	32.1 (7.1)
Collar Size (inches)	16.6 (2.1)
Epworth Score	13 (2)
Sleep Latency (min)	18.2 (23.4)
PLMS Index	31.5 (38.7)
Sp02 T3 (%)	94 (2)
ODI T3 (/hr)	7.1 (3.6)
AHI T3 (/hr)	8.1(3)
Sp02 A1 (%)	92 (4)
ODI A1 (/hr)	17.7 (12.1)
AHI A1 (/hr)	18.4 (12)

Table 1. Patient demographics

P35 - 129XE VENTILATION MRI AND LCI TO ASSESS ACUTE MAXIMAL EXERCISE AS A METHOD OF AIRWAY CLEARANCE IN CYSTIC FIBROSIS

Mr Laurie Smith[1,2], Dr Helen Marshall[1], Dr Graham Norquay[1], Dr Guilhem Collier[1], Mr Oliver Rodgers[1], Dr Paul Hughes[1], Dr Alberto Biancardi[1], Dr Noreen West[2], Dr Martin Wildman[3], Dr Alex Horsley[4], Prof. Jim Wild[1]

1. *POLARIS, University of Sheffield, Sheffield, United Kingdom*
2. *Sheffield Children's Hospital NHS Foundation Trust, Sheffield, United Kingdom*
3. *Sheffield Teaching Hospitals NHS Foundation Trust, Sheffield, United Kingdom*
4. *Manchester CF Centre, Manchester, United Kingdom*

Introduction: Exercise is increasingly utilised as a method for airway clearance in CF, yet the acute effects of exercise on regional lung ventilation are unknown. Hyperpolarised gas ventilation MRI (V-MRI) is highly sensitive to ventilation defects in CF, making it suitable for assessing the efficacy of airway clearance. Here we assessed the effect of cardio-pulmonary exercise testing (CPET) on the distribution of ventilation using V-MRI and lung clearance index (LCI).

Methods: Patients performed two baseline 3D V-MRI's, and LCI was measured by washout of SF_6 on air. This was followed by a maximal CPET, after which V-MRI and LCI were repeated. The ventilation defect percentage (VDP) was used to quantify the proportion of lung without ventilation on V-MRI. The two baseline scans were used to assess VDP repeatability.

Results: 13 patients with CF were assessed; mean (SD) age=25.2 (10.1)years, FEV_1=-1.8 (1.7) z-score. VDP from baseline scans showed Bland-Altman limits of agreement of -1.8 to 1.4%; significant change in VDP was set at >1.6%.

Post-CPET, there was a significant reduction in VDP and LCI ($p<0.05$). 11/13 patients had a visual change in ventilation distribution: 9 subjects had at least partial resolution of defects whilst 2 patients had new ventilation defects appear. Overall 7/13 patients had significant change in VDP. The 2 patients with new ventilation defects post-CPET both had normal FEV_1 (>-1.64 z-score) but also low VO_2 at peak exercise and anaerobic threshold (AT), and were outliers when correlating VO_2 with VDP. Excluding these 2 outliers, VDP significantly correlated with VO_{2peak} (r=-0.86) and VO_{2AT} (r=-0.88).

Conclusions: For some patients, acute maximal exercise directly affects the distribution of ventilation in CF, likely due to re-distribution of mucus caused by large increases in ventilation during exercise. Deconditioned patients may benefit from exercise-based airway clearance.

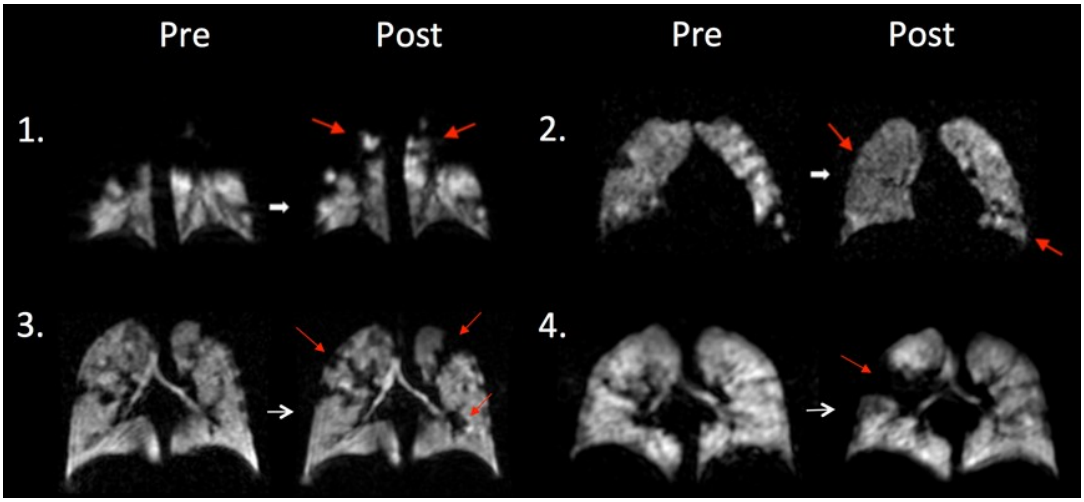


Figure 1: ^{129}Xe ventilation MRI in four patients (1-4) pre and post CPET. Post exercise, patients 1 and 2 have significantly improved VDP and have areas of visual improvement in the distribution of ventilation. In contrast, patients 3 and 4 have a worsening in the distribution of ventilation post exercise, with new ventilation defects appearing. Red arrows depict areas of the lung, which have either improved ventilation post exercise, or depict a worsening in ventilation.

P36 - AN EVALUATION OF CONCORDANCE OF SLEEP STAGE SCORING: EVIDENCING STANDARDS AND QUALITY ASSURANCE IN NHS LOTHIAN

Mrs Laura Jess[1]

1. *NHS Lothian, Edinburgh, United Kingdom*

Introduction

In 2013, the American Academy of Sleep Medicine (AASM) published results from the Inter-Scorer Reliability (ISR) programme in the Journal of Clinical Sleep Medicine[1]. The conclusions detailed suggest that whilst using AASM guidelines for scoring, concordance and inter-scorer agreement of sleep stage scoring should exceed 83%. As a method of monitoring quality assurance in sleep stage scoring in NHS Lothian, required concordance should exceed 85% with comparison to a Senior Sleep Physiologist in possession of the RPSGT certificate. This standard conforms and exceeds the expected concordance stipulated by the AASM.

The purposes of this evaluation are to ensure inter-scorer agreement standards continue to exceed AASM recommendations and local concordance protocol levels, and to provide an ongoing record of quality assurance for the Sleep Service in NHS Lothian.

Method

Between April 2018 and January 2019, four concordance studies were set by the Chief Physiologist. Sleep Physiology staff (n = 8; n = 1 Chief Physiologist and n = 7 Sleep Physiologists), were required to score the set studies and concordance of Apnoea Hypopnoea Index (AHI) and sleep stage scoring (total concordance, N2 and N3, Wake, NREM, REM) were compared to the Chief Physiologist study. Trends in data were identified and discussed.

Results: see table below

Discussion

Concordance over the four-study average indicates inter-scorer agreement standards continue to exceed AASM recommendations and local concordance protocol levels (range 85.58% - 91.97%). Minimal variations in AHI were noted between the Chief Physiologist and inter-scorer agreement, indicating no difference in treatment options or variation in patient outcome.

1. Rosenberg RS; Van Hout S. The American Academy of Sleep Medicine inter-scorer reliability program; sleep stage scoring. J Clin Sleep Med 2013;9(1):81-97.

	Study 1 (±SEM)	Study 2 (±SEM)	Study 3 (±SEM)	Study 4 (±SEM)	Four-Study Average (±SEM)
Sleep Staging Total Concordance (%)	91.00% (±1.26%)	79.50% (±4.59%)	90.80% (±1.92)	81.00% (±1.41%)	85.58% (±6.18%)
Sleep Staging Concordance N2 and N3 (%)	92.17% (±0.75%)	82.33% (±4.76%)	92.80% (±1.92)	83.00% (±1.41%)	87.58% (±5.68%)
Sleep Staging Concordance Wake, NREM and REM (%)	95.00% (±0.89%)	89.17% (±3.49)	95.20% (±1.30)	88.50% (±0.71%)	91.97% (±3.63%)
AHI (Absolute/Average)	22.43/16.59	13.21/11.47	20.00/27.20	10.39/7.01	12.11/9.59

P37 - A RETROSPECTIVE REVIEW OF SURVIVAL FOLLOWING NON-INVASIVE VENTILATION SUPPORTED PERCUTANEOUS ENDOSCOPIC ENDOSCOPY IN PATIENTS WITH MOTOR NEURONE DISEASE.

Mrs Joanna Shakespeare[1], Mr Edward Parkes[1], Dr Asad Ali[1]

1. *Uhcw Nhs Trust, Coventry, United Kingdom*

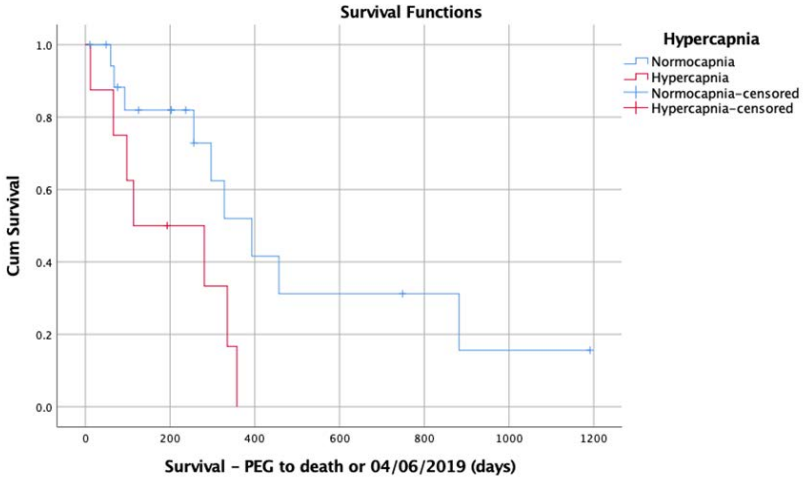
Motor Neurone Disease (MND) is a neurodegenerative disease resulting in progressive muscle weakness leading to impaired control of movement, breathing and swallowing. Malnutrition is associated with a decrease in muscle strength and increased patient mortality[1]. Percutaneous endoscopic gastrostomy (PEG) placement is indicated in patients with symptomatic dysphagia and/or significant weight loss[2].

Despite limited data to support the specific timing of PEG, it is generally recommended before forced vital capacity (FVC) falls below 50% predicted[3]. Due to the risk of PEG placement in MND patients with respiratory compromise, non-invasive ventilation (NIV) is being increasingly used as ventilatory support during the procedure. We undertook a retrospective review of outcomes of NIV supported PEG procedures in our MND population.

Between 30.07.2013 and 24.05.2019, 31 (18M) patients, mean age 66.87 +/- 8.74 years underwent gastrostomy supported by NIV. One patient died within 30-days (12 days) of PEG placement. Overall mean survival was 402 +/- 77.20 days. Survival was not influenced by MND site of onset (bulbar or limb) (Log Rank p=0.156) or prior use of NIV (Log Rank p=0.123). Only 3/26 (12%) patients had an FVC <50% predicted (1/3 achieving quality assured standards) and this was not found to influence survival (Log Rank p=0.695). A significant survival difference was observed in hypercapnic patients ($paCO_2$ >6.0kpa) (Figure 1) prior to PEG (Log Rank p=4.669, p 0.031). Cox-regression analysis however (HR 8.9, 95% CI 0.893-89.47, p 0.062) demonstrates that this was not statistically significant.

In our single centre, small cohort study, our data suggests that pre-procedure hypercapnia may offer additional prognostic information. Mean survival in our patient group was better than that reported in the literature (402 (95% CI 184 to 389), 260 (95% CI 209 to 297), respectively) days. Sequential measurements of FVC are important in the monitoring of respiratory compromise however ABG measurements are also recommended to allow holistic patient assessment especially as the accurate determination of FVC can be difficult in patients with predominately bulbar impairment.

1. Desport, 1999
2. Miller, 2002
3. American Academy of Neurology



P38 - CAN ANTHROPOMETRIC INDICES AND EPWORTH SLEEPINESS SCORE (ESS) PREDICT TYPE OF DIAGNOSTIC TEST TO INVESTIGATE OSA?

Mrs Devra Hepple[1], Mr Ian Cliff[1]

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Introduction

OSA is the 3rd most common respiratory disorder in the UK (NICE, 2018), and is estimated that 1.5 million adults are affected, with a possible 85% of those undiagnosed. The Sleep service at RSUH has seen an exponential increase in the number of referrals to the service, with on average a 17% increase per annum over the last 5 years. The current pathway involves patients initially having overnight oximetry however, if this is inconclusive, a limited sleep study follows. This aim if this study was to assess if anthropometrics could be used to predict the first line investigation.

Method

A retrospective three month audit of 208 patients (138 male, 70 female) referred to the sleep service was conducted. Information regarding diagnostic investigations and anthropometric values were obtained and compared. A p value of 0.05 was used as the level of significance.

Results: see Table

From the 208 patients, 52 (25%) went onto CPAP following oximetry. The remaining 156 required LSS, which confirmed CPAP in 88 cases. 61 were discharged and the remaining 7 went on to PSG. The oximetry confirmed CPAP group had increased BMI, ODI and collar size were generally older. When comparing the LSS confirmed CPAP with discharge or PSG, differences in BMI, ODI and AHI were seen.

Conclusion

The results show that age, BMI and collar size are useful predictors of OSA and a requirement for CPAP therapy. However, the measure of ODI and AHI remain the best measures for adherence to current guidance.

	Oximetry	Oximetry + LSS		CPAP after oximetry + LSS	Discharged after oxime-try + LSS	
Parameter	Mean (SD)	Mean (SD)	p-value	Mean (SD)	Mean (SD)	p-value
Age	54.78 (1.86)	50.65 (1.08)	*0.0504*	53.07 (13.04)	48.60 (14.04)	*0.0246*
BMI	37.63 (1.23)	32.237 (0.576)	*0.0001*	33.59 (6.586)	30.75 (7.83)	*0.0052*
ODI	51.59 (3.65)	7.110 (0.634)	*<0.0001*	9.939 (9.272)	3.293 (1.94)	*<0.0001*
Collar size	17.673 (0.263)	16.513 (0.594)	*<0.0001*	16.444 (1.731)	16.76 (11.81)	*0.9020*
ESS	10.615 (0.666)	9.195 (0.447)	*0.0878*	9.820 (5.710)	8.068 (5.298)	*0.0724*
AHI		21.00 (1.63)		32.05 (20.45)	6.060 (4.570)	*<0.0001*
Male	39	99				
Female	13	57				