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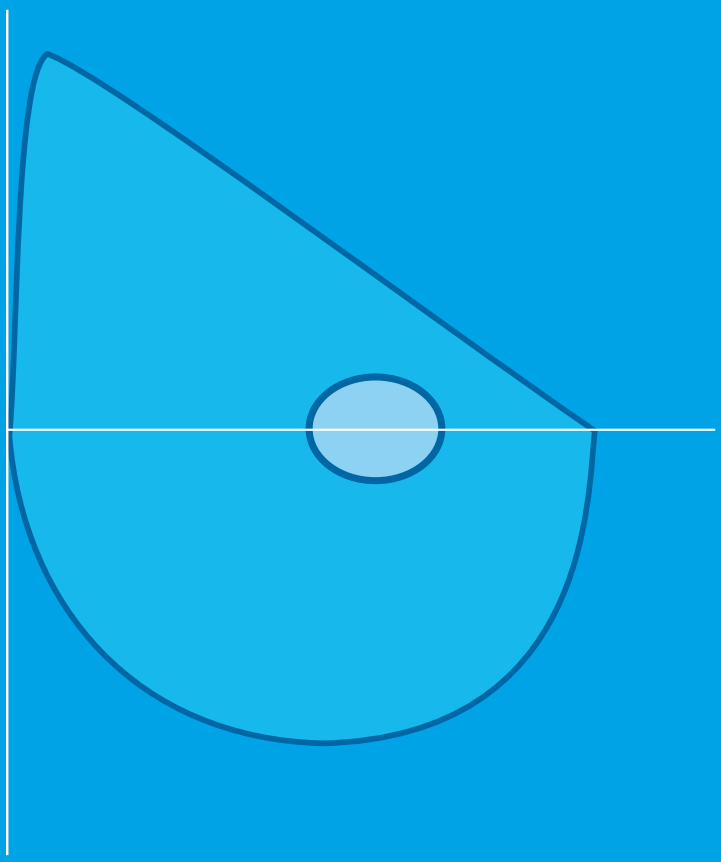
Inspire



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The Official Journal of the Association for Respiratory Technology & Physiology

Inspire

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Articles in bold are from ARTP travel bursary winners

FIRST WORD

Welcome to the new edition of Inspire. The leaves are rapidly disappearing from the trees and the first emails giving dates for 'flu vaccinations have hit my inbox – I suppose that means that we are well into autumn now. For me, that means two things – the start of the new academic year (is it just me, or are medical students really getting younger?) and the beginning of the run-up to the Annual Conference. We will be going back to Hinckley at the end of January – those of you that were there last year will know how good the venue is. I don't know if karaoke is on the schedule for this conference, but I can guarantee that I won't be giving my tonsils a workout – my voice only works when diluted with 67000 others at Murrayfield Stadium.

When the ARTP announces the Conference, they also announce that a number of bursaries will be available, to allow members to attend the conference and have their registration paid. There is of course a little payback required for this largesse. You do need to exercise your "little grey cells" and produce an article for this very Journal. Have a look through this issue and you will find three very different types of bursary article, which illustrate the range and the quality of the articles submitted.

The problem is, that the ARTP receives about 25 bursary requests a year – not just for the Annual Conference, but for BTS and ERS meetings as well. I did a quick calculation yesterday: If everybody who had applied for and had been given an ARTP travel bursary submitted an article for Inspire I would have enough material to fill each issue for the next three years. As it stands, I have enough material in my laptop for the next issue, and that's it. Is it really THAT daunting to write 1500 words? We are all supposed to be scientists in this profession. One integral aspect of being a scientist is communication. We need to learn about new techniques of relevance to our work and we also need to communicate the results of our own research to others as well. Unless you are prepared to drive round every Lab in the country and tell everybody what you have done (and I can imagine your service manager may have some views on that) the most effective way to communicate is to write a paper.

I'm the first to acknowledge that writing a paper for publication in a peer-reviewed journal can be a headache – I have just had one of my papers accepted after going though eight drafts. That's not typical, and most papers for Inspire are usually accepted on the first or second draft. We all need to find a place to learn our trade. A friendly, helpful organisation such as the ARTP and this Journal provide the ideal place for you to develop your writing skills. The members of the Editorial Board and myself are more than happy to offer advice on how to approach the subject. Any of the more veteran members of the profession (and you know the sort of person I'm talking about) should be happy to help anybody take the first steps in your writing career. Please don't be put off if things don't go as you want them to. One of my favoured sayings comes from John F. Kennedy – there is no such thing as a stupid question, just an unclear explanation of a concept. Have another go, ask somebody else for their opinion and then one day you will get the "click" and everything will start to come together.

It has been suggested by some of my more militant colleagues on the ARTP Executive that we should operate a "name and shame" policy for members who back out of submitting an article, which isn't a route I'm keen to take, but I won't rule it out either.

Being a canny bunch, the ARTP don't hand out travel bursaries in advance – only after delivery of the goods will we cough up. In an average year we only give away about half the money we could, and in my opinion that is a real shame. Is not writing an article for Inspire really worth about £300? Come on folks – get those creative juices flowing!

Andy Robson, Editor

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EXTREME PHYSIOLOGY: ARE FLIGHT ASSESSMENTS BENEFICIAL?

By Nick John
Senior Clinical Physiologist, Lung Investigation Unit, University Hospital Birmingham NHS Trust

Introduction

With an estimated one billion passengers travelling by air each year, ever increasing numbers of people with chronic respiratory diseases wish to travel but may be unaware that the pressurized cabin of a modern aircraft may be physiologically challenging to them. A large percentage of those will therefore need hypoxic challenge tests (HCT's, commonly referred to as "Fitness to Fly" assessments). These passengers fall within the category of patients seen within Lung Function departments up and down the country with varying degrees of background respiratory complications. With the absence of formal guidelines, recommendations for physicians requesting flight assessments are of more pertinence in order to allow patients to fly safely and prevent untoward in-flight incidents such as those reported by a recent North American service offering expert assistance by radio link for in-flight medical emergencies that logged 8,450 calls in 2001, of which 10.2% were respiratory in nature (1).

At the altitudes most commercial airlines cruise at (40,000ft), internal cabin pressures are not able to be maintained at sea level (partial pressure of O_2 21kPa) but are kept fairly stable at an equivalent altitude of 8000 feet or 2438 metres (partial pressure of O_2 approximately 14kPa) which equates to an equivalent sea level fraction of inspired oxygen (FiO_2) of 15%. Healthy individuals are able to tolerate such a reduction in the partial pressure of oxygen and remain free from respiratory distress despite a reduction in PaO_2 to between 7.0-8.5 kPa (53-64 mmHg, SpO2 85-91%) for flights lasting as long as 20 hours - such flight times more recently being possible with the introduction of the Airbus A380. In those with chronic respiratory disease and other conditions associated with moderate to severe hypoxaemia at sea level, altitude exposure may exacerbate such pre existing hypoxaemia to the extent of employing physiological compensations such as mild to moderate hyperventilation (moderated by the fall in $PaCO_2$) and moderate tachycardia. Subsequent clinical manifestations include euphoria, headache, fatigue, lassitude and dizziness.

Clinical Pre Flight Assessment

The objective assessment of risk to patients of hypobaric hypoxia can be performed via a number of methods of which the current "gold standard" is still the hypobaric chamber HCT which is both expensive and not widely available so will not be covered further.

The 50 metre walk

Traditionally favoured by the airlines, the 50 metre walk test is simple; however there is no evidence to validate it. Despite being a basic assessment, this physiological response to an exercise load is a good test of cardiorespiratory reserve and can also act as a crude simulation of the stress of the additional hypoxaemia patients will experience at rest during a flight. Patients with borderline HCT results can utilise other walking tests such as the 6 or 12 minute walk and the incremental shuttle walk test in order to further examine the impact of exertion on a moderately hypoxic patient and indeed the potential of exertional desaturation during a long haul flight such that may be experienced walking along aisles.

Predicting hypoxaemia from equations

The use of predicting altitude PaO_2 or SpO_2 from equations is used more frequently by clinicians (e.g. in primary health care) who do not have access to the facilities required to perform a HCT. However these equations will have been derived almost exclusively from patients with COPD who have had measurements of PaO_2 in a hypobaric chamber, or before and during a HCT. In spite of the use of FEV_1 to improve accuracy of these predicted equations, they are disadvantaged by the fact that the 90% confidence limits are ± 1 kPa (~ ±2-4% SpO_2) (2) and have been challenged in patients with COPD when compared with hypobaric results. In one recent study predictive equations considerably overestimate the need for in-flight O_2, compared to HCT (3). Despite this and with the obvious shortcoming of not simulating flight duration and cabin conditions, the predictions are suitable to establish upper and lower limits for 'no in-flight oxygen required' (SpO_2 > 95%) or 'in-flight oxygen needed' (SpO_2 < 92%).

Hypoxic challenge test

The assessment most frequently used in which the subject is exposed to breathing from a hypoxic environment is that of the hypoxic inhalation test, fitness to fly test, flight assessment, hypoxic gas mixture testing or HCT depending on which terminology is routinely used. This method of clinical pre flight assessment has been utilised for many years in both research and clinical assessment (4). Here the assumption is made that breathing a low FiO_2 at sea level reproduces the hypobaric hypoxia of altitude. To achieve the FiO_2 of 15% necessary to re create an altitude environment (approx. 8000ft) can be done in several ways. These include an appropriate mix of oxygen and nitrogen in Douglas bag, pre-prepared special gas mixture available from manufacturers of 15%, filling a plethysmograph with 15% O_2 or using a Venturi mask of either 35-40% using nitrogen as the driving gas to create an FiO_2 between 14-16% oxygen*. The use of pulse oximetry and blood gas analysis is recommended during these methods to demonstrate a reduction in PO_2 to below 6.6kPa (<85% SpO_2), although these values are subjective, with such a result suggesting the need for in flight oxygen.

*(Editor's note: I would recommend using 40% Venturi masks only)

Are flight assessments beneficial?

Air travel is in general safe, even for those with medical conditions, and there are no established methods for determining morbidity associated with air travel (5). In order to fully ascertain the usefulness of HCT in regards to the true benefit to patients, a large deal of research is still needed. However there seems to be little doubt that the potential harmful effects of hypoxia induced via air travel can be prevented through the use of in flight supplemental oxygen. These tests need to continue to be requested by consultants and performed by appropriately trained physiologists in all patients who are deemed at risk of becoming overly hypoxic during a commercial flight. Indeed these patients may have relatively normal blood gas status in the hospital setting as it has been found that a resting arterial oxygen tension greater than 9.3 kPa at sea level does not exclude development of severe hypoxaemia particularly in COPD patients during air travel (6).

Further comparisons of the methods of assessing the response of a broad range of patients to breathing from a hypobaric environment are still needed in order to gain a national and international consensus on the optimum mode of evaluation. To perform a comparison study of patients with severe respiratory failure receiving oxygen during a flight and then withholding the oxygen on the return flight to compare physiological response would not be deemed ethical.

With the British Thoracic Society Standards of Care Committee producing interim recommendations for managing passengers with respiratory disease planning air travel and the development of future guidelines, continued numbers of patients routinely seen in lung function departments by members of the ARTP can carry on enjoying the safety of air travel.

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E-MAIL FORUM DIGEST

Ciaran McArdle, Birmingham Childrens Hospital

For the benefit of those members who do not yet have access to the E-mail forum here is a synopsis of some of the messages and discussions that have been 'posted' between 01/04/2008 and 30/09/2008.

Things seemed to have been fairly quiet in Forum Land recently, especially over the summer months. Whether this has been due to the big bosses taking their extended holidays leaving everybody else to cope with stretched services or everybody being depressed by the weather is not clear.

Fortunately there have been a few juicy topics to review one of the most interesting being a brain teaser via **Rachel Holt**. Basically the question posed was how long would it take a person (with a tidal volume of 500ml) to die as a result of re-breathing CO_2 in a sealed 2x2x1m box? After the obvious answer; putting a consultant in and performing a real life experiment (**MB, BC**), a complicated answer; working out of the increase in CO_2 allowing for the resultant hyperventilation (**KH, BC, NC**), an opposing view; that the main problem would be hypoxaemia as opposed to hypercapnoea (**AM, AC**), we finished up with a theoretical answer; applying Schreodingers' 'cat in a box' principle that the person may occupy two states at the same time i.e. have the possibility to be both simultaneously alive and dead (**Sarah Blain**).

Onto more routine matters and **Lee Watts** inquired about performing a hypoxic challenge on a COPD patient with an FEV_1 of 20% pred. Should the patient be assessed solely on the ability to maintain blood gases on supplemental O_2 or, does the risk of volume expansion causing tension pneumothorax contraindicate flying anyway? According to **DC** while the degree of hypoxaemia and ability to obtain decent blood gases on supplemental oxygen is the primary requirement for performing this test he always comments on the amount of gas trapping present since isolated bullae can potentially increase by up to 38% during a flight. Furthermore whilst there has apparently been only one recorded instance of a death from flying (related to gas trapping) it remains at clinician discretion since there is no agreement as to what degree of gas trapping represents a significant contraindication.

Meanwhile **Ella Clarke** asked for clarification as regards what constitutes a significant fall (in actual volume rather than percentage terms) when performing supine spirometry. According to J Hughes & N Pride (Lung Function Testing p53) a postural change in VC is usually around 200mls (**AC**) based on the reference *'Michels A, Decoster K, Derge L, Vleurinck C. Influence of posture on lung volumes and impedance of respiratory system in healthy smokers and non smokers. J. Appl Physiol 1991;71:294-9'*, so a fall of 400mls should be significant. Supine spirometry is however an approximate screening test and this should then be a cue to perform MIP/MEP and or SNIP tests (**BC**).

Finally on a related theme **Alison O'Brien** wondered whether when interpreting MEP, MIP and SNIP a lower limit of normal ($>80cmH_2O$) or different predicted equations should be used? Apparently a lot of the confusion arises from the fact that different interfaces and leaks within a system can lead to lower values (KH). Most opinion seemed to come out on the side of a cut-off point part of the reason being that the tests are volitional tests and low values are therefore difficult to interpret. As such a good suggested starting point was the 2002 statement on respiratory muscle testing (Am. J. Resp. Crit. Care Med. 2002, 166: 518-624) which states the cut-offs should be:

SNIP >-60 (f), >-70 (m)

Pimax >-60 (f), >-80 (m)

Pemax >60 (f), > 80 (m)

For children, **Ged Rafferty** supplied 2 useful references; Rafferty, G. F., Leech, S., Moxham, J. & Greenough, A. (2000). Sniff nasal inspiratory pressure in children. Pediatric Pulmonology **29**, 468-475 *and* Stefanutti, D. & Fitting, J. W. (1999). Sniff nasal inspiratory pressure: Reference values in Caucasian children. Am. J. Resp. Crit. Care Med. **159**, 107-111.

DO PATIENTS WITH BETTER EXERCISE CAPACITY COPE WELL WITH THE ANXIETY AND DEPRESSION INDUCED BY THE NEW DIAGNOSIS OF LUNG CANCER?

Motty Varghese, St. James's Hospital, Dublin, Ireland.

Introduction

Cancer remains a life threatening illness with fears about incapacity, disfigurement and death. The psychological burden this can cause to the subject in the form of anxiety and depression is common. There is extensive scientific literature linking lack of physical exercise with depressed mood, limited coping skills and reduced psychological well-being. The association between depression and medical problems can be linked to reduced physical activity and increased sedentary behaviour. Exercise offers multi-factorial benefit during periods of well being. More research need to be done to establish the positive effects of better exercise capacity during periods of medical problems.

The aims of the study were to find out the prevalence of anxiety and depression in newly diagnosed lung cancer patients and to find out whether patients with better exercise capacity in terms of VO_{2max} coped well with the psychological stress brought by the new diagnosis.

Methods

We investigated 18 patients (10 males) with lung cancer who were potential candidates for lung surgery. The mean age was 64 yrs (range 43 – 79). These patients underwent cardiopulmonary exercise test as part of their pre operative assessment for lung surgery and were asked to complete a Hospital Anxiety and Depression Scale questionnaire to evaluate their psychological well being. Anxiety and depression scores were obtained for each patient and were checked for correlation with their respective maximal oxygen consumption using a Pearson correlation coefficient.

Results:

The ratio of male to female subjects for this study is 10:8. The patient age group ranged between 43 and 79 with a mean age of 64 years. The analysis of HADS revealed that 9 patients (50%) had abnormal anxiety levels and 5 (28%) had depressive status. The correlation between maximal oxygen consumption and anxiety levels (Fig. 1) in the whole group showed a medium negative correlation (r = -0.4). Depression levels (Fig. 2) also exhibited a medium negative correlation (r = -0.5).

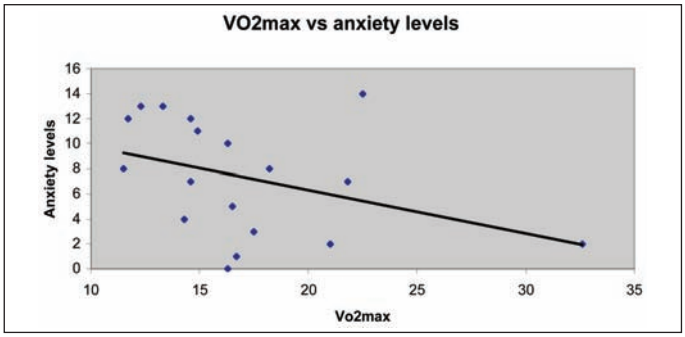

Figure:1

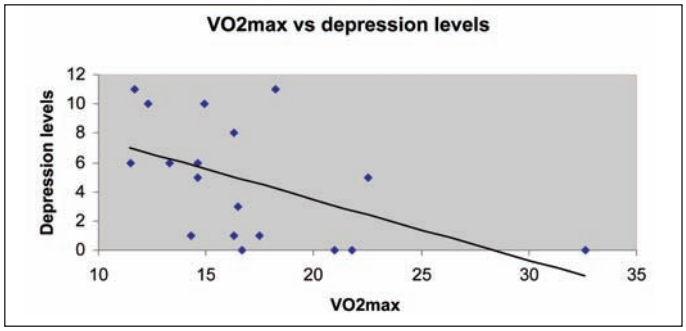

Figure:2

Conclusions

This study indicates that anxiety and depression are prevalent in patients with lung cancer. The study underlines the benefits of regular physical activity during well being and diseased condition by exhibiting a relationship between VO_{2max} levels and anxiety and depression in this group of patients. Patients with better exercise capacity seem to have coped better with the psychological stress of new diagnosis than patients with reduced exercise capacity. The study is ongoing to evaluate the same in a larger sample size.

Recommendations

Screening every single patient to evaluate their psychological health will be important to provide them with optimum psychological support which in turn can affect the outcome of the treatment of cancer. The importance and benefit of regular, and optimum physical activity has to be adequately made known to develop the habit of regular exercise.

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2. Hopwood, P., Stephens R.J. Depression in patients with lung cancer: Prevalence and risk factors derived from quality-of-life data. *J. Clin. Oncol.* **18:** (2000) 893.

ON THE BLOWER

By Alan Moore, Nigel Clayton and Brendan Cooper

Are cassette based blood gas machines a clinically robust technology ?

There are now cassette based blood gas analysers available from two of the major blood gas players – Instrumentation Laboratory (IL) and Radiometer. The beauty of these devices, as the companies will be only too keen to tell you, is that they are essentially maintenance free. This yields a significant manpower saving which, of course, has to be traded off against the costs of the cassettes. Basically each cassette contains a given number of tests and you pick the type of cassette which gives you the parameters you require from basic blood gas parameters through to metabolites, electrolytes and co-oximetry. The other plus side to these devices apart from the saving in manpower is that, should the cassette become inoperative due to an internal error or clot, then there will be a procedure to reclaim the unused portion of the cassette by means of a credit system with the supplier.

So, by now, you're wondering what all this is about. Well, we've had two incidents recently where, despite the best efforts of the companies involved, there were problems with the results supplied from two devices – one from IL, the Gem 400 and one from Radiometer, the ABL 88.

The GEM 4000 is sold as a device which has IQM – which we presume stands for Intelligent Quality Management. Basically, it is supposed to take care of all its QA as and when required so that daily or more frequent QA's by the user are not necessary. However, there have been a number of problems.

Firstly, there is a reported problem of Haemoglobin determination. Most blood gas analysers do not measure Haemoglobin unless the device has a co-oximetry module. Basically, they measure Haematocrit (Packed Cell Volume) and use an algorithm to estimate Hb with typical accuracy being ± 0.9 g/dL which is adequate for blood gas purposes. The problem is though that this technique works poorly on 60 μL capillary samples with Hb values in the 25+ g/dL being reported. These equate to Haematocrit values being determined of >75% which is physiologically impossible.

Secondly, it was reported that wild discrepancies were being encountered in blood gas determinations when compared to other blood gas machines when the GEM 4000 was not calibrated immediately prior to a measurement being made. This should not be required but calibration appeared to rectify the discrepancies. This was confirmed by wildly varying WEQAS (the external QA scheme for blood gas analysers) reports despite the GEM 4000 reporting that everything was hunky dory.

The response to the latter problem was a further software amendment which also took away the facility to manually instigate a calibration – a move about as useful as a chocolate tea pot.

To be fair to IL, they have responded to all complaints promptly but the problem lies in the fact that the UK is a mere puppet of the main European operation based in Italy which, again, is a puppet of the American master organisation. The simple message here in respect of the GEM 4000 is caveat emptor – 'buyer beware'.

Problems have also been found on the Radiometer ABL 80 Flex portable blood gas machine. Firstly there has been problem with the software which showed that the analysers were making large errors in the analysis of blood gases to the tune of between 1-3 kPa for both PaO_2 and $PaCO_2$. This has been satisfactorily resolved by Radiometer in the UK with a software fix. This error was picked up in the procurement process against an existing machine before being used clinically. What is more worrying is that the product may have been purchased as a new analyser in primary care and operators would not be aware that there was an error. This emphasises the importance of having not only procurement process and internal checks but also external (e.g. WEQAS) QA programmes.

Just as Radiometer cleared up that problem, they got a "dodgy" batch of electrolyte cartridges – which meant further time undertaking procurement checks before the error was found. Credit to the company, they resolved the problem, alerted all of their customers and footed the bill for any wasted cartridges. Every company can have problems like this, it shows the quality of that company as to how they deal with the problem. Credit over recent years must go to DeVilbiss and ResMed who have done a great job looking after

customers when this happens. Any manufacturer wondering how to win an ARTP award needs to think about these issues when dealing with customers. In this case, 2 previous ARTP Manufacturer Award winners have ridden these storms and come out shining!

AM/BC

The Takeover Merry Go Round

Well, we seem to be into takeover season. So far within recent times we've had Cardinal Health take over VIASYS, Philips take over Respironics and the Australian business press is full of speculation that Linde are pursuing Resmed. It remains to be seen whether this comes to fruition. I would have my doubts about this press speculation but there is little doubt that publicly quoted companies of the size of Resmed are prime targets for take over. Whether take over means good or bad things is always difficult to judge. There is no doubt that any takeover creates massive disruption whilst all back office functions are "rationalised". This happens in all takeovers. It is sad to see that there were a significant number of job losses resulting from the Cardinal Health acquisition of VIASYS and it is particularly sad that there were a significant number of UK job losses including many at MicroMedical.

I have reliable information of 'merger' talks at an advanced stage between two of the current 3 American owned PFT companies. This is not however a merger. From the information I have, it is in fact one company in financial difficulty approaching another one to save its bacon. What will no doubt happen is that the merger will become a purchase when the stock price of the company in trouble is low enough to match the price the other company is prepared to pay which I suspect in the case of this deal is probably around half of $25 million original asking price. USA law prevents one company from creating or strengthening a monopoly so I'll leave it up to you to work out who this refers to.

As we submit our copy for print, I am hearing further information on another major international company wanting to make its way into the CPAP and Home care market. I might well lay bets on Johnson and Johnson if I were a gambling man. As we have mentioned previously in this column over the years, globalisation has a significant effect on the lung function and respiratory care market, a pattern that is set to continue into the future. Companies become "brands" and delivery of service and development of equipment is more about corporate structures that customer requirements. Clearly a balance is needed between competition and monopoly.

AM

A Question of Credibility

We are fortunate that most of the company representatives and engineers that we deal with from day to day are honest and hard working. It is unfortunate therefore when an incident is reported to us where the honesty and credibility of one or more individuals in a company is called into question. What is even worse is when the response from the company when we formally raise a complaint via Manufacturers Liaison Committee is to dishonestly blame our members. In such a situation, ARTP Manufacturers Liaison Committee (MFL) will leave no stone unturned in ensuring that those responsible are bought to book.

In this incident which we are reporting to you, a nSpire service engineer alleged that he had attended a department following a call for service from the department. As far as the department were concerned, the engineer never set foot on the premises, and when nSpire were asked to produce a signed copy of a service visit report, a copy of a scribbled note not on an official service report was produced by the service engineer as evidence that he had made the visit and completed the work. The department disputed the engineers account of events and having not received a satisfactory response from Michael Hinds, UK General Manager, nSpire, asked MFL to take the issue up on their behalf.

MFL looked at the facts of the case and, knowing which department it was and the physical layout of the department, we found it absolutely inconceivable that a service engineer could walk down a very long corridor, pass upwards of a dozen room doors, not find any staff available, not knock on any doors, find the equipment in question carry out the repair, make no further attempt to locate a member of staff and leave the premises without having been observed by anyone. Further, service engineers are always required under service contracts to report to the department staff and obtain a signature to prove that the work has been completed to the department's satisfaction.

So, this "scarlectric pimpernel", was not seen, he did not obtain a signature from a member of the department team and he failed to produce an official service report document. What would you think of this? The upshot of this poor customer care and the handling of this was the removal of a senior company manager.

We congratulate the CEO of nSpire for taking our complaints most seriously and it is good to see that there is integrity at the highest level of nSpire. Furthermore, the company reduced the service contract to that department for the next year by 5%. That's good customer care!

As for the service engineer in question, he resigned from nSpire shortly before the manager was dismissed. He is now employed elsewhere in a lung function company in the UK. We hope he's learned a very sanguine lesson!

AM

ARTP users meet with Breas Medical, DeVilbiss Healthcare, ResMed and Respironics

On 26 March 2008 NICE issued its Health Technology Appraisal for Continuous Positive Airways Pressure (CPAP) for sleep apnoea. The document recommends nasal CPAP as an effective technology treatment for Obstructive Sleep Apnoea Hypopnoea Syndrome (OSAHS). The consequence of this document is the likely expansion in OSAHS diagnostics and CPAP assessment / issue, and a change in the way the service is delivered. In future we may well see the independent sector, CPAP companies and Primary Care diagnosing and treating OSAHS.

The risk to patients of an uncontrolled expansion without adequate quality of service is that sub-optimal service could be delivered with a variety of standards of care and ultimately ineffective and inappropriate treatment being delivered. Currently, there are no published or recognised standards of care or voluntary code of conduct for the delivery of CPAP treatment for OSAHS in the UK.

To ensure that standards are maintained by all providers of CPAP treatment, a group of ARTP sleep specialists met with Breas Medical, DeVilbiss Healthcare, ResMed and Respironics on 13th February to discuss expected standards of care for sleep apnoea services. In record time, aimed to coincide with the publication of the NICE document on 26th march, the ARTP published the "ARTP Standards of Care for Sleep Apnoea Services". This is referred to in both the NICE document and on the BTS web site under clinical information for sleep.

This document describes the minimum standards of care for sleep apnoea services together with a code of conduct that will protect patients and maintain high standards of quality care for CPAP services whoever delivers them. ARTP expect to consult with other interested professional organisations to gain approval (i.e BSS, BTS, ARNS, ACPRC, etc.).

To view the ARTP Standards of Care for Sleep Apnoea Services document go to the news section on the ARTP web site. To view the NICE document go to:

http://www.nice.org.uk/guidance/index.jsp?action=byID&o=11944

Special thanks go to Alan Moore, Brendan Cooper, Keith Butterfield and Mark Atkins for producing this document in such a short period of time.

NC

New Devices Available

For the first time in a number of years, there are some new, useful devices around. Morgan Scientific were showing a very neat Isothermal flask for body box calibration at ATS. As many of you will know, Morgan Scientific is headed by Patrick Morgan, son of Philip. Patrick works out of the USA. What is very clever about this device is you can use it to verify the performance of any body box. It is battery powered and operated by Bluetooth from a PDA. Medisoft users will be interested to know that their software will enable them to use the device without a PDA. I understand the device will be available via Pulmolink. There are 2 flasks at different volumes and you can vary the speed of the calibration pump to check out what effect this has on measurements – something no other system permits.

At ATS, I had a meeting with the Rudolph brothers – owners of Hans Rudolph inc and I let them know that we were unhappy in the UK with having to go through a Polish dealer and pay in Zlotys in we wished to

purchase the Hans Rudolph DLCO calibrator. As you will all know, we have a perfectly good Hans Rudolph distributor in the UK – Cranlea and Co. who have given us good service over many years and I informed the Rudolph Bros. that they were unlikely to achieve any UK sales through a Polish dealer. As I expected from such sensible people, they have reconsidered and the DLCO calibrator is available via Cranlea & Co. Now all that remains is to negotiate a sensible price for the beast ! Currently these can be purchased for around about £6000 (without carrying case!). For a couple of calibration syringes, a stand with cylinder holders and some tubing, this is pretty steep. More realistic pricing would lead to greater take up in the lung function community.

Once in a while, a piece of new technology arrives in the UK which is awesome. Such a device I believe is the OB1, a high frequency ventilator which can be used both invasively and non-invasively and with which there is absolutely no risk of barotrauma as it has an open circuit. The device is a masterpiece of physics using a triple venturi device at its heart. Developed during the cold war for military applications and only now coming to light and being made available in the West, the applications of an active expiration phase without risk of barotraumas are immense not only in helping to remove secretions but a whole host of applications. The device is available from Stephen Connelly who some of you will remember from VIASYS and is available through his company Special Care Technologies Ltd – www.sctl.co.uk

In the same vane, a device from Italy called UNIKO is to be made available in the UK. From the evidence presented to me to date, this simple device which applies a 1 cm oscillating positive pressure change (TPEP) during expiration appears to have remarkable effects on removing secretions, reducing air trapping and improving drug penetration. Carina VT will be supplying the UNIKO in the UK following its official release at the ERS in September 2008.

For more information, take a look at the web site www.mpr-italy.it/en/prodotti.html

AM

New to the market is an environmentally friendly one way valve spirometry mouthpiece. Manufactured by UBLOW, this device replaces the plastic one way valve with a paper valve. These cost £20 for 200 which is cheaper than the equivalent mouthpiece sold through the NHS supply chain. For more information, take a look at the web site www.ublow.co.uk

NC

Vitalograph now produce the "Vitalink" General Practice Management System. The software allows an automatic two-way interface between the Vitalograph Spirotrac software and EMIS. Automatic data transfer prevents transcription errors and ensures that test data is attached to the correct subject with the correct read codes.

Vitalograph also continue to expand their filter range. The following coloured filters are now available:

White - Sensor Medics

Blue - Vitalograph, Micro Medical, MIR

Clear - Jaeger

Teal - nSpire

Green - Med Graphics

Congratulations to the team of Vitalograph employees who recently undertook the gruelling '3 Peaks Challenge' in support of the British Lung Foundation. Having climbed Scafell Pike, Snowdon and Ben Nevis in just 24 hours, the triumphant Vitalograph team raised £657.91 for the British Lung Foundation. This is becoming a bit of a trend, since two ARTP Executive members (Brendan C and Martyn B) have this summer also been involved with separate 3 Peaks Challenges. These are truly excellent events and are great at building teams and generating lots of money for charity. It begs the question – isn't it about time ARTP and respiratory manufacturer's had a competitive 3 Peaks Challenge for BLF?

NC

Moving on to sleep, Braebon has just released the second generation of the MediByte snoring and apnoea recorder. This is a 12 channel recorder designed for home use. In addition to parameters measured on earlier models, the latest device now includes respiratory inductance plethysmography technology, EMG, thermal and pressure airflow sensors, snoring audio playback and decibel volume. All this for a system which costs around £3,000.

NC

DeVilbiss Healthcare has just introduced the SmartLink system for monitoring and reporting data compliance when using the SleepCube range of CPAP's.

The SmartLink module connects to the back of the SleepCube. Patient data and CPAP setting information can be entered into the desktop software and is then transferred to the SmartLink Module using a standard SD card. Once the study is complete data from the SmartLink is then transferred to the desktop software using the SD card / USB card reader for analysis and reporting.

The SmartLink can also be used to initiate split night studies when using it with the SleepCube Auto and the data card can be used to update the systems firmware.

DeVilbiss Healthcare has recently obtained global exclusivity for the distribution of Innomed/RespCare CPAP interfaces.

The Hybrid is a modern twist on the traditional full face mask with three sizes of cushion and pillows. It is designed to help eliminate the pressure points on the forehead and across the bridge of the nose.

The Bravo is a nasal pillows interface. It is also available with three pillow sizes which are interchangeable.

The Nasal-Aire II is a very quiet nasal prongs interface designed to help to reduce the feeling of patient claustrophobia.

NC

Not So New Devices

I have been dealing with CosMed the Italian lung function manufacturer who not only make some good spirometers, but also the excellent K4 portable exercise system. We have been having problems with their Quark PFT2 lung function equipment which was donated to the department in a Clinical Trial. We had tried to use the "Closing Volume " facility for a year or two with little success. However, I am pleased to report that the company have upgraded the software and got the measurement up and running very well. You may remember this measurement was devised by our great friend and colleague Milic-Emili (ARTP Special Award Winner – and Zorba the Greek dance specialist!). It is used to measure the closing volume of the small airways as a result of dynamic collapse and is useful in assessing airway function in COPD for example.

There is a lovely story about the day Professor Milic-Emili called his new research fellow into his crowded Hammersmith Hospital office and inhaling on a cheroot (as chest specialists did in those days!!!!) and then exhaling the smoke in a long slow blow into a beam sunlight, he asked the research fellow did he notice how the concentration of the smoke increased at the end of the exhalation. "Well that's what I want you to research for the next year!" And so the closing volume measurement was born. Classic physiology! Of course the Fletcher and Peto data that is used to death in COPD showing the decline in lung function over adult life was based on studies in smoking and non-smoking GPs! Who said smoking was ALL bad! How times have changed!

BC

Changing faces at nSpire Health

nSpire health have announced that Tim Flanagan is now the new health representative following Ian Waller's move back in to clinical practice. Tim has many years experience supporting customers in the NHS and Private sectors.

NC

Don't forget, if you have any problems regarding equipment malfunction, quality control / calibration, service response times, software issues etc. please feel free to voice your opinions off the forum by contacting the Manufacturers Liaison Committee direct at Watchdog@artp.org.uk. We will then be able to collate this information, including verification of accuracy, before commencing on an appropriate course of action.

PRESS RELEASE

RESPIRATORY ACHIEVERS OF THE YEAR AWARDS RECOGNISE OUTSTANDING CONTRIBUTIONS TO LUNG HEALTH

The Respiratory Achievers of the Year Awards, newly launched this year by the British Lung Foundation in partnership with Vitalograph, recognise both the outstanding achievements of people with lung conditions and of those who care for them.

The awards ceremony will take place in London on November 14th. The winners will be selected from the following four categories:

- Health Professional Respiratory Achiever of the Year
- Patient Respiratory Achiever of the Year
- Junior Respiratory Achiever of the Year
- Respiratory Carer of the Year

"We are delighted that this event will recognise people who have succeeded in improving the lives of those who have lung disease or who have made great personal achievements despite having a lung condition themselves," says Dame Helena Shovelton, Chief Executive of the British Lung Foundation.

"Although there are more than seven million people with a lung condition in the UK, it is a 'hidden disability'. People with lung disease can look well on the outside but experience severe restrictions on their mobility and ability to undertake day-to-day activities, such as getting dressed or cooking a meal. Because of this they often feel their disease is overlooked by health and social services. This event will allow us to thank patients, carers and health professionals alike for all their hard work and positive contributions during the past year."

Lung disease is the second biggest killer in the UK, claiming 117,456 lives in 2004. Non-respiratory cancers account for only slightly more deaths (122,500 in the UK in 2004). More people die from respiratory disease in the UK than from ischaemic heart disease (106,081).

One person in every seven in the UK – or eight million people - is affected by lung disease. It costs the NHS and society £6.6 billion: £3 billion in costs to the care system, £1.9 billion in mortality costs and £1.7 billion in illness costs. And an estimated 24 million consultations with GPs were for respiratory disease in 2004 at a cost of £501 million to primary care.

"We are honoured to be a part of the Respiratory Achievers of the Year Awards and to applaud the efforts of those who demonstrate that living with a respiratory condition is no barrier to achievement," says Bernard Garbe, Managing Director of Vitalograph, a leading provider of respiratory diagnostic devices, clinical trials and medical equipment servicing. Its lung function test equipment is used in primary care, occupational health, sports medicine, asthma management and hospitals.

Mr Garbe will be one of the judges of the awards, alongside respiratory specialist Professor Mark Britton and Professor Sue Hill, Chief Scientific Officer at the Department of Health.

Dame Helena adds: "Lung function technicians play a vital role in diagnosing lung disease, but post-diagnosis, one of the biggest problems that sufferers face is gaining information about their condition and its impact on their lives.

"The British Lung Foundation is the only UK charity that supports people with all different kinds of lung disease. It has a network of more than 200 "Breathe Easy" support groups across the UK; offers help and advice through its helpline and produces a wide range of information and publications that are available both in printed form and on its website.

"We successfully launched the BLF Nurse programme two years ago and now 23 nurses are operating in six areas of England and Scotland: in Glasgow, Odham, Bristol, Sefton, Central Lancashire and Calderdale. They deliver expert care and support to patients and carers in their own homes and also deliver tailored education programmes to community matrons, district and practice nurses, pharmacists, physiotherapists and other health professionals. BLF Nurses help by monitoring patients' conditions, stabilizing their conditions and with advice on lifestyle, nutrition and medication.

Another vital role for the charity is funding research. Over the past 20 years it has invested more than £18 million on nearly 300 research projects across 43 different lung conditions, helping to improve our understanding of lung disease – its prevention, diagnosis and treatment."

The British Lung Foundation website is at www.lunguk.org and its helpline on 08458 50 50 20 is open from 10am to 6pm, Monday to Friday. It is staffed by experienced respiratory nurses, parent counsellors, a paediatric nurse and welfare benefits advisers, who are all glad to offer help and advice.

Vitalograph is a world-leading provider of outstanding quality respiratory diagnostic devices, clinical trials and medical equipment servicing. With a pioneering heritage of excellence, spanning half a century, Vitalograph continue to make valuable contributions to effective medical care and enhanced quality of life.

ADJUSTMENT OF DIFFUSING CAPACITY FOR CARBON MONOXIDE (DLCO) FOR HAEMOGLOBIN VALUE IN UK LABORATORIES

Harry Patel, Department of Respiratory Medicine,
The Dudley Group of Hospitals NHS Trust, Dudley.

Introduction

The ATS/ERS guidelines on standardisation of lung function testing state that DLCO change can be substantial as a function of haemoglobin concentration. DLCO results should be adjusted to the known haemoglobin concentration for the patient or to a standard haemoglobin value of 14.6 g.dl-1 for males and 13.4 g.dl-1 for females[1].

Methods

To assess compliance with these guidelines we surveyed 225 respiratory laboratories in the UK asking whether DLCO adjustment for haemoglobin was part of their routine clinical practice. We also reviewed DLCO requests and results from our respiratory laboratory over a 3-month period.

An electronic questionnaire was sent to one physiologist (lead, senior or service manager) in each of the laboratories. One and a half months were given to complete and return the questionnaire.

The questions were aimed to gain an insight into:

- Whether the doctor (requester) had an opportunity to quote the Hb value
- How often the laboratory thought the Hb value was actually quoted
- What the laboratories standard Hb value were if not quoted
- Whether the TLco result was corrected for the known Hb value

Results

One hundred and one (45%) completed responses were received (Figure 1); forty seven (21%) questionnaires were undeliverable due to recipients having high anti-virus protected computers, and incorrect or inactive email addresses; seventy seven (34%) did not respond.

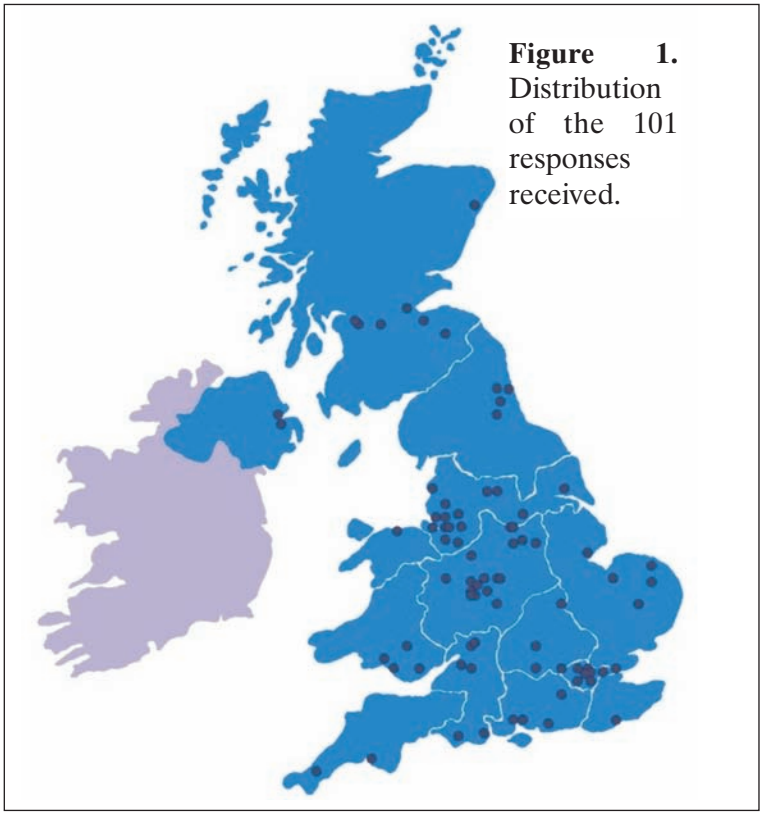

Figure 1. Distribution of the 101 responses received.

Fifty-three laboratories use a request form, which has a section for the haemoglobin value.

Sixty-eight laboratories reported that the haemoglobin value was only rarely recorded on the request form with only 1 laboratory indicating the haemoglobin value was included the majority of the time.

Some additional comments from the questionnaires possibly explained why...

“In general terms, we only correct TLco for Hb when the patients come from Oncology, BMT, Liver of Renal services as these patients are more likely to a) actually have an Hb and b) it’s usually low. In our service most of the time, the chest physicians do not seem that interested in Hb!”

“We look Hb up on hospital results system and correct all anyway. We never ask for clinicians to quote Hbs - they’d only get it wrong anyhow!”

“I redesigned our PFT request forms and considered having a Hb box... pointless, as for the majority of the times the form is not filled out correctly anyway. A recent Hb is rarely found in their notes, unless they have had an ABG, which is unlikely in routine out patients.”

"On our request card we have a section which asks the doctor to provide a Hb 'only on those patients which they would like a Hb correction' rather than for every patient that gets referred for TLCO. I think that partially explains why we rarely have a Hb provided."

If the haemoglobin value was available 74 laboratories would adjust the DLCO value routinely as per the guideline, 8 would not provide an adjustment irrespective of the haemoglobin value and 19 would adjust if the haemoglobin value were outside a specific range (e.g. 11-19 $g.dl^{-1}$).

322 DLCO tests were carried out at our large district general hospital over the 3-month period March-May 2007 (routine outpatients with or without a respiratory disorder). 55 (17%) requests included the haemoglobin value on the form (a section for haemoglobin value is part of the request form). Using the hospital electronic results system a further 93 patients were identified as having had a haemoglobin value within the 2 weeks prior to the test. In 12 of these 148 patients, the adjusted DLCO result changed the severity category of the reduction of DLCO[2] (Table 1). Also from this group, the haemoglobin value of 38 patients' fell outside their normal expected range.

Table 1. Interpretative DLCO results before and after haemoglobin (Hb) adjustment.

Number of Patients	Original DLCO Result	Adjusted DLCO result for Hb
3	Normal	Mild
3	Mild	Normal
3	Moderate	Mild
2	Mild	Moderate
1	Severe	Moderate

Where...

DLCO Degree of Severity	DLCO as % Predicted
Normal	> Lower Limits of Normal (LLN)
Mild	> 60% and < LLN
Moderate	40 – 60%
Severe	< 40%

Conclusions

∑ The majority of UK laboratories do not adjust DLCO values for haemoglobin concentration.

∑ In 8% of cases in our hospital, haemoglobin adjustment changed the severity grading of the decrease in DLCO possibly influencing clinical management.

∑ Approximately 26% of haemoglobin values fall outside the normal range for both males and females, indicating the importance for adjustment.

∑ Increasing use of electronic pathology results systems allows easy access to haemoglobin results enabling adjustment to be made in a substantial number of patients tested. Future respiratory diagnostic equipment linked to such systems could improve haemoglobin adjustment.

References

1. ATS/ERS Task Force: Standardisation of lung function testing. Standardisation of the single-breath determination of carbon monoxide uptake in the lung. Eur. Respir. J. (2005) **26**: 720-735.

2. ATS/ERS Task Force: Standardisation of lung function testing. Interpretative strategies for lung function tests. Eur. Respir. J. (2005) **26**: 948- 968.

PATHOPHYSIOLOGY AND LUNG FUNCTION MEASUREMENTS IN PULMONARY FIBROSIS AND CYSTIC FIBROSIS

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This article looks at the differing pathophysiology of two lung conditions – pulmonary fibrosis and cystic fibrosis. Regular measurements of lung function in respiratory conditions are essential to aid management. An overview of how results from tests of dynamic and static lung volumes and carbon monoxide transfer factor (TL_{CO}) in these two conditions may be affected are summarised below.

Pulmonary fibrosis

There are over 100 different restrictive ventilatory defects of which pulmonary fibrosis is one. They have a common pathophysiology, but changes depend on the underlying aetiology. Causes of pulmonary fibrosis are shown below (Table1.), although often the cause is unknown. Common presenting symptoms are a dry, irritating, unproductive cough and dyspnoea, with rapid shallow breathing, which becomes significantly evident on exercise. In severe cases cyanosis may be observed at rest.

Table 1. Causes of pulmonary fibrosis. Adapted from Lumb (2000)

Causes	*Subgroups*	*Examples*
Drug induced	Anti-cancer	Bleomycin, busulphan, cyclophosphamide, methotrexate
	Antibiotics	Isoniazid, nitrofurantoin, sulphonamides
	Others	Amiodarone
Dust	Inorganic	Silicosis Asbestosis
	Organic	Farmer's lung
Infections	Viral	Viral pneumonia HIV
	Other	*Mycoplasma* Opportunistic infections
Systemic disease	Connective tissue disease	Rheumatoid arthritis, scleroderma, systemic lupus erythematosus, ankylosing spondylitis
	Others	Sarcoidosis, histiocytosis, uraemia
Miscellaneous	Acute inflammation	Acute lung injury, adult respiratory distress syndrome
	Inhalation injury	Smoke, cadmium, sulphur dioxide
	Radiation lung damage	
	Cryptogenic fibrosing alveolitis	

The pathological changes that occur with pulmonary fibrosis are induced by an immunological response, which may involve the alveolar walls, air spaces, blood vessels and small airways. The inflammation leads to thickening of the interstitium in the alveolar wall where new collagen forms, laid down by fibroblasts in a cellular healing process, which results in an excessive amount of collagen (Figure 1).

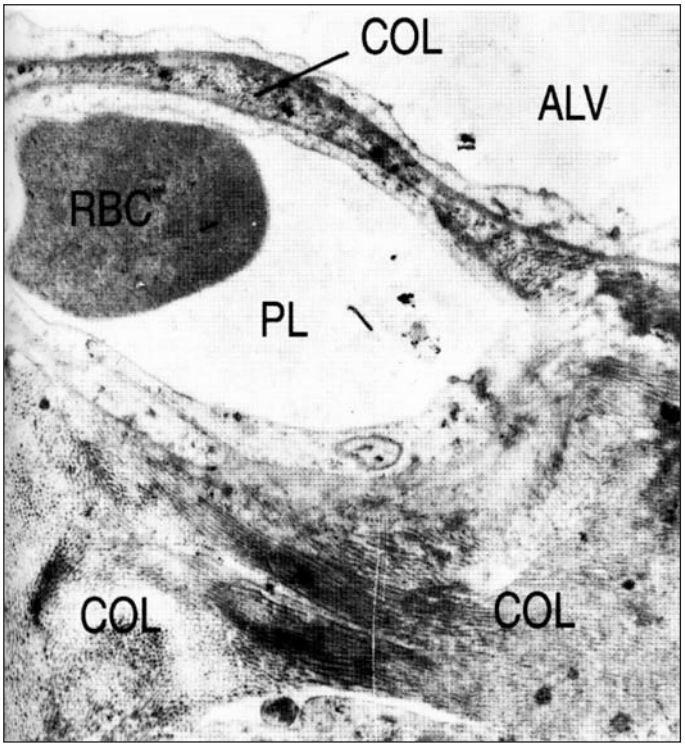


Figure 1. Electron micrograph from a patient with diffuse interstitial fibrosis. Adapted from West (1997)

COL - the increased amount of collagen

ALV - alveolar space

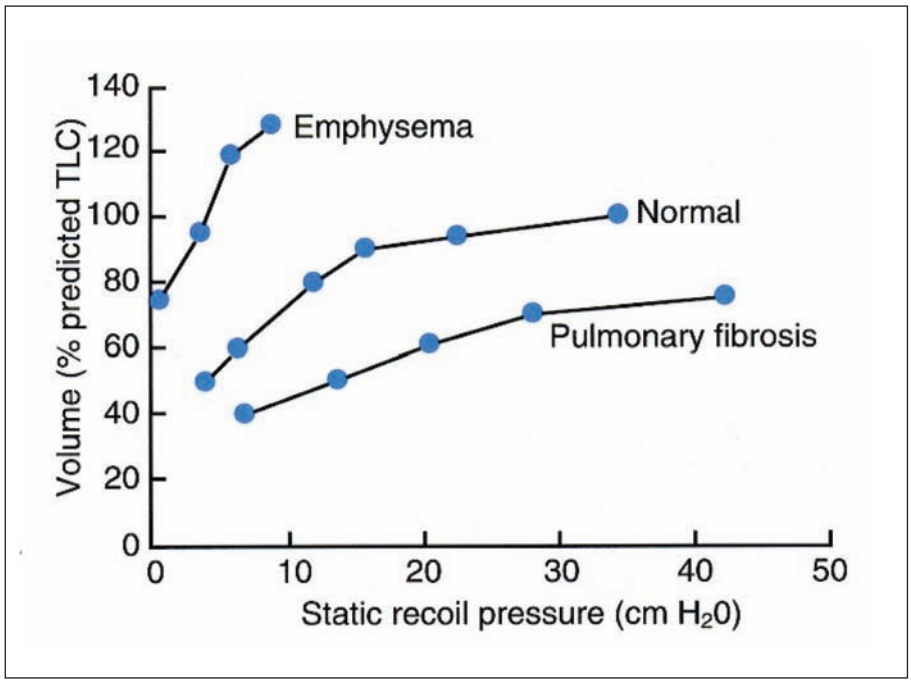
RBC - red blood cell

PL - plasma

As the lung tries to continually repair itself the amount of elastin is reduced. This alteration in the lung elasticity, decreases compliance and leads to collapse of the walls in the alveoli and small airways, this reduces the area available for gas exchange and leads to maldistribution of ventilation (Figure 2).

Figure 2. Pressure-volume relationships for individuals with: emphysema, pulmonary fibrosis and individuals with normal lungs. The flatter the curve, the lower the compliance.

Adapted from Grippi (1995)



In advanced cases, scarring occurs, which can be seen on CT scan and shows a characteristic “honeycomb lung”, due to the thickened tissue; cystic spaces filled with air and dilated bronchioles.

The loss of elastic tissue and the increase in fibrotic tissue means that the lungs become stiffer and harder to inflate resulting in a restrictive pattern of disease. This leads to an increase in the work of breathing, when the lung has to overcome the elastic forces and airways resistance (Figure. 2).

There are three possible pathological patterns that may occur in the alveolar walls (Figure. 3):

- Inflammatory pattern – due to an accumulation of inflammatory cells, the walls become thickened
- Fibrotic pattern – thickening of the alveolar walls occur due to an increase in fibrous tissue due to fibroblasts in the interstitial space
- Lung destruction – In advanced disease a CT scan of the lungs show a ‘honeycomb’ appearance, caused by thickened tissue and air cysts.

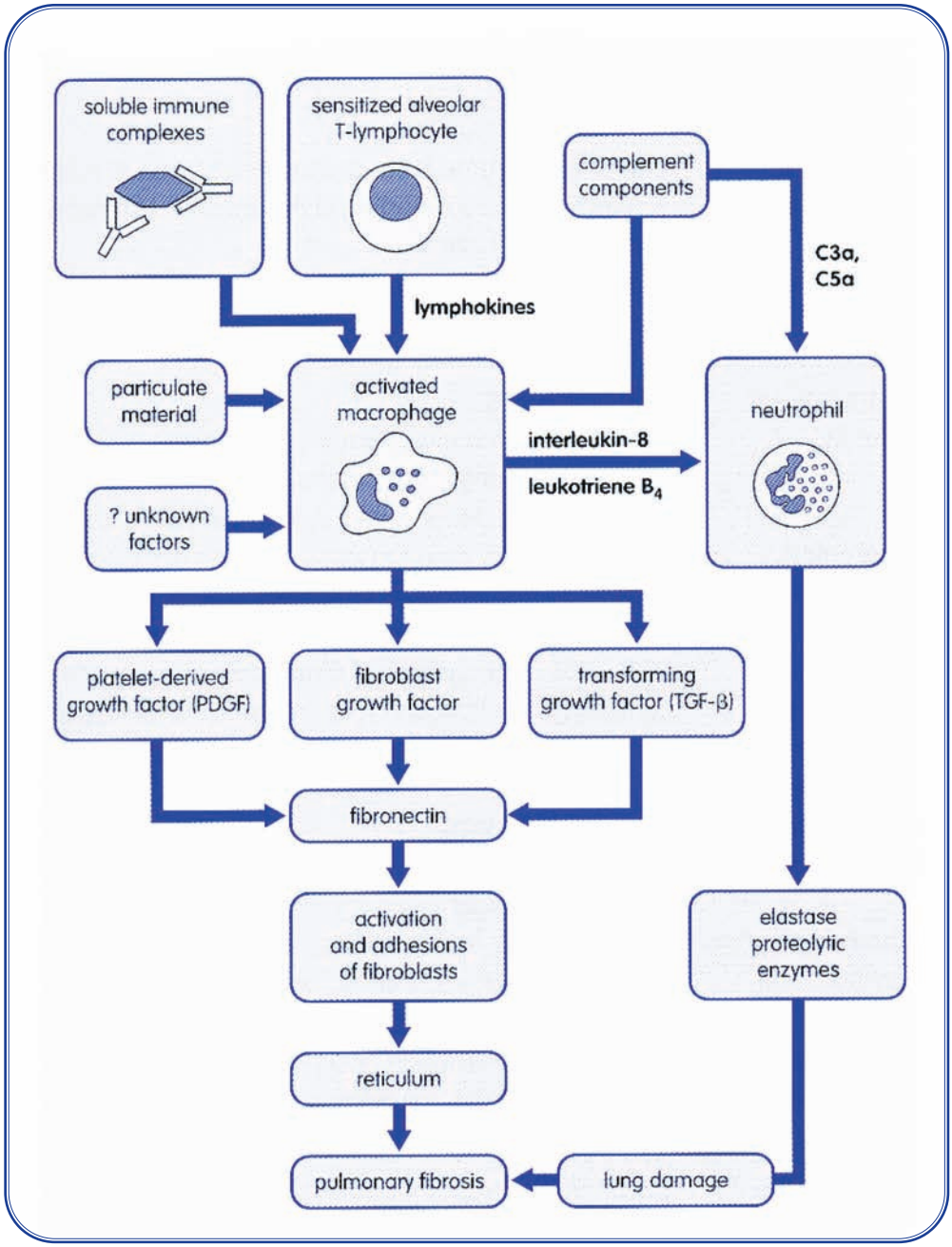


Figure. 3. Pathogenesis of pulmonary fibrosis. Adapted from Jefferies (1999).

Increased inflammatory cell numbers cause changes in the alveolar air spaces, although in interstitial lung disease the predominant changes occur in the alveolar walls where cellular infiltration leads to thickening, and fibrosis.

As fibrosis progresses, the elasticity in the lungs is reduced, resulting in the collapse of the alveolar and small airways, which leads to a decrease in compliance, and the area available for gas exchange.

Hypoxemia is a manifestation of the disease, due to the pathological changes that occur in the alveolar walls, air spaces, blood vessels and small airways.

The structural changes that occur in fibrosis lead to functional changes that can be monitored using lung function tests. The diagnosis of restrictive disease can be aided by results of lung function tests, which demonstrate a specific pattern.

Static lung volumes

As a consequence of inflammation and fibrosis, a decrease in lung compliance and the thickening in the alveolar walls, causes fibrotic changes and can lead to an overall reduction in lung volumes. Total lung capacity (TLC), functional residual capacity (FRC) and residual volume (RV) are all reduced although the relative proportions are preserved. (Figure. 4)

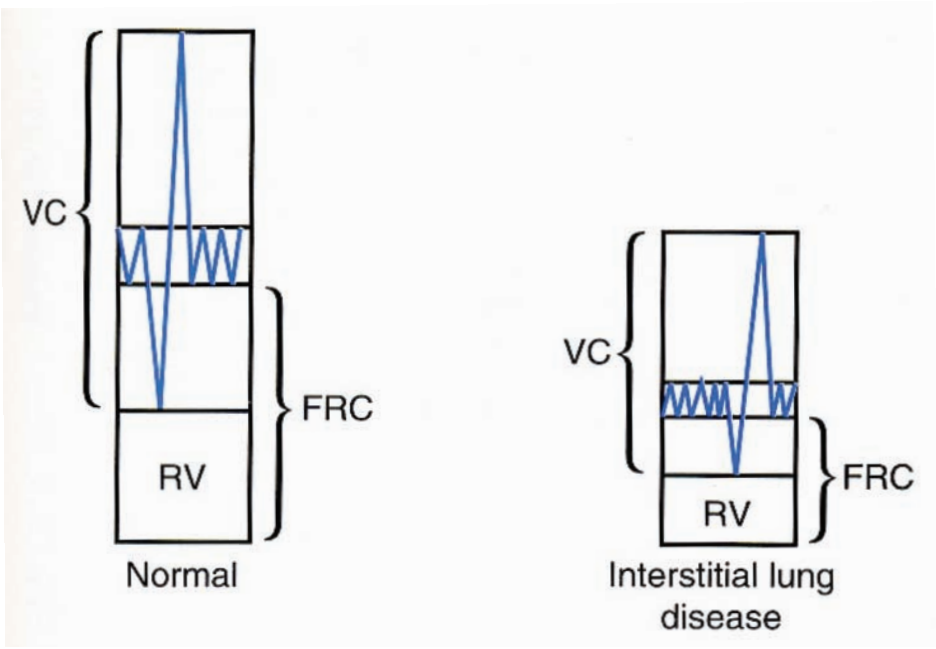


Figure. 4. Changes in lung volumes. Adapted from Grippi (1995).

The fibrous tissue in the alveolar walls inhibits lung distensibility and means an increase in transpulmonary pressure is needed to inflate the lung at any lung volume.

During forced expiration the airways are prevented from collapsing by the increased tension, which may lead to a reduction in RV (Figure. 5).

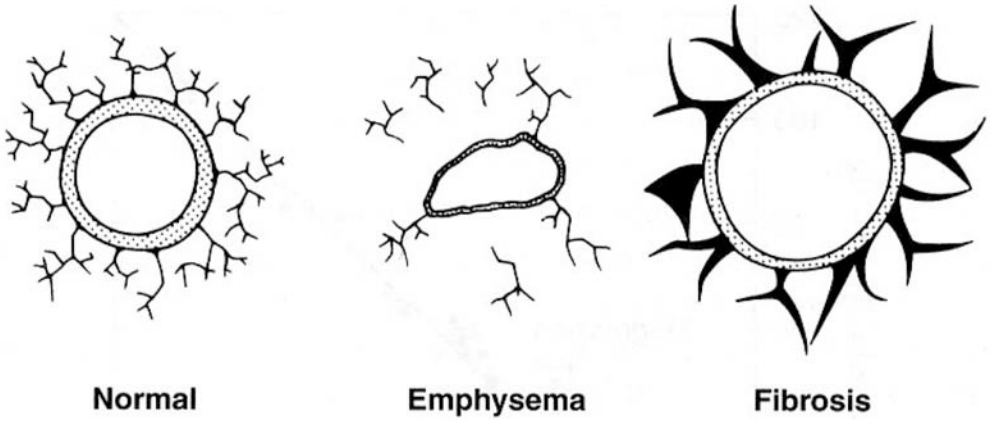
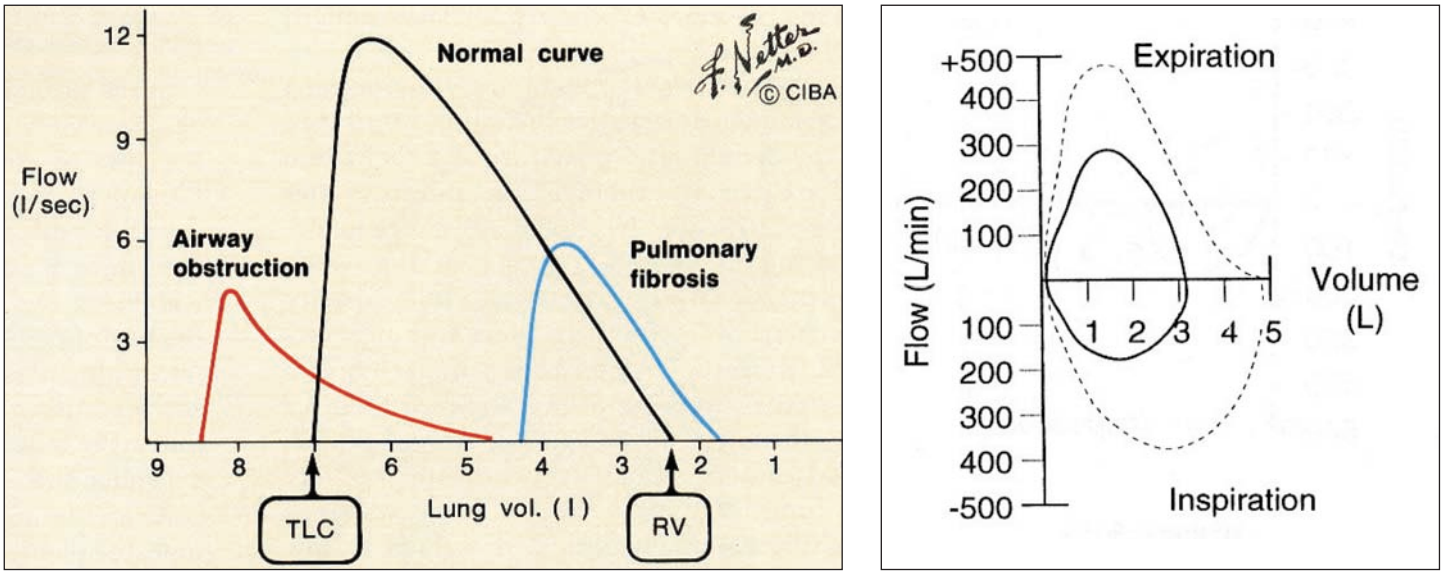


Figure 5. Airway calibre in fibrosis. Adapted from West (1997).

Dynamic lung volumes

Spirometry results will reveal restrictive pattern where both the FVC and FEV1 are reduced but the FEV1/FVC ratio is normal or increased.

Recording the flow-volume curve is useful as forced expiratory flows are normal or high and the curve is a distinctive shape that is typical of restrictive disease (Figure 6).



A) B)

Figure 6. Examples of flow volume curves. Adapted from Altose (1979).

A) Shows typical curves for obstruction, normal and restrictive patients related to absolute lung volume

B) Shows a restrictive pattern (bold line) on spirometry in comparison to the normal patient (dashed line)

Traction on then airways leads to increased maximal expiratory flows, although with progression of the disease TLC, VC and maximal flows decrease even though when compared to normal airways, the affected airways have a larger diameter, due to the higher elastic recoil, at a given lung volume.

Carbon monoxide transfer factor (TLco)

With fibrosis ventilation – perfusion mis-matching occur and although total minute ventilation increases to attempt to compensate for the reduction in O2 delivery to poorly ventilated areas, an inequality of ventilation to perfusion arises.

As the disease progresses, the thickness of the alveolar walls and fluid in the air spaces, inhibits the diffusion of O2 into the capillary blood. The diffusion of gas into the blood can be measured using the single breath carbon monoxide transfer factor (TLcosb) technique. The TLco measurement is reduced in people with pulmonary fibrosis and is a useful tool in monitoring disease progression.

The reduction in TLco is caused by:

- Thickening of the blood gas barrier
- Reduced capillary blood volume (as part of the fibrotic process destroys the blood vessels)
- ventilation perfusion mis-match
- Changes in the surface area of the lungs

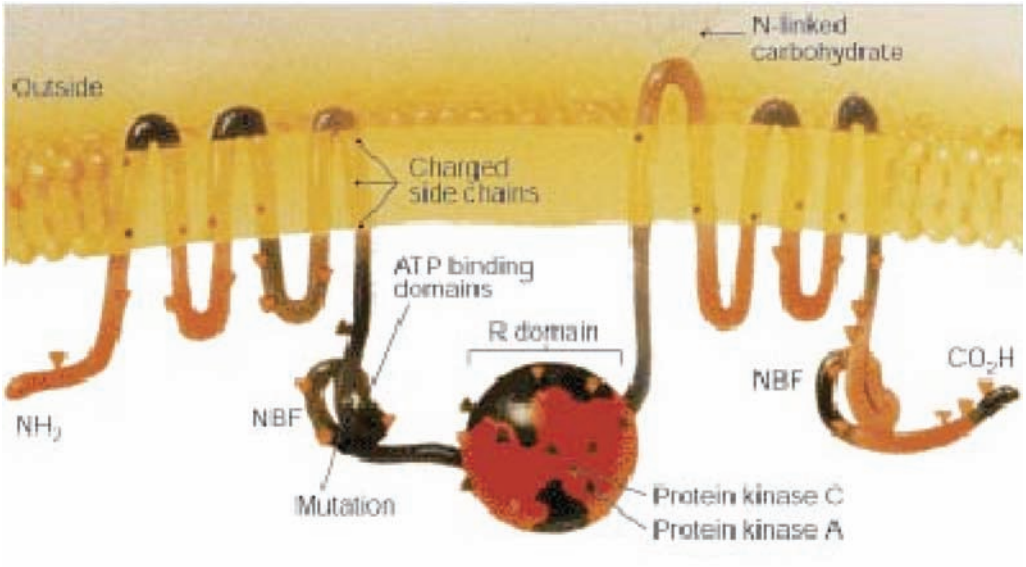
Cystic Fibrosis

Cystic Fibrosis (CF) is an autosomal recessive genetic disease, which most commonly occurs in Caucasian people, in developed countries. The incidence is approximately 1 in 2500 live births in the UK, with 1 in 25 carrier prevalence in the population. If both parents are carriers of the gene, their baby has a 1 in 4 of having CF. The CF gene is located on chromosome 7. Over 1000 different mutations have been discovered, the most common is delta F508.

It is systemic disorder of the exocrine glands where the transport of chloride and sodium is affected. The CF transmembrane conductance regulator (CFTR), responsible for ion transport across the epithelial cells, is defective (Figure. 7). This results in water being drawn into the cells (by osmosis), as they are impermeable to chloride ions, which means the mucus secreted into the airway becomes dehydrated and viscous in nature causing disruption and impairment of the mucociliary escalator, leaving the airway prone to inflammation, colonisation of bacteria and

recurrent respiratory infections. There is also abnormal transport of sodium across the epithelium, which can lead to an increase of sodium being pumped through the cell. Similar mechanisms affect the bilary tract, reproductive system and pancreas.

Figure 7. CFTR Membrane – links the outer and inner cell membrane and is found in the epithelial cells. Adapted from Wikipedia (2007).



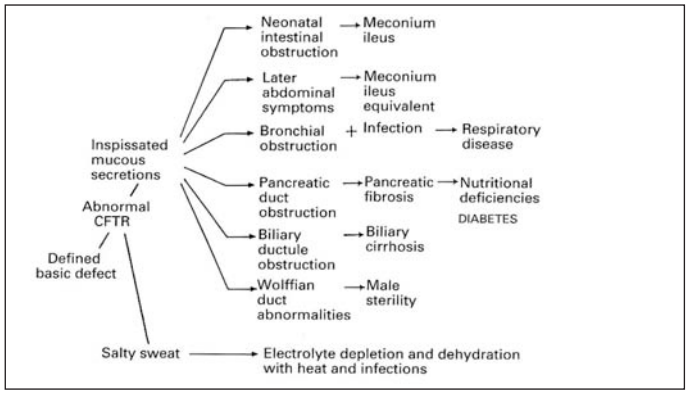
CF is a multisystem disorder, where the principal organs affected are:

- Lungs
- Gastrointestinal tract
- Hepatobiliary system
- Pancreas
- Skin
- Sweat glands
- Reproductive system

Survival has improved greatly over the last 30 years and many patients now survive into adulthood due to improved and more aggressive treatment regimes. The most common cause of death is respiratory failure associated with pulmonary hypertension and cor pulmonale.

The pathophysiology of CF

The underlying defect on the CFTR and the ineffective inflammatory response process in CF, leads to increased viscosity of bronchial secretions, which with the impaired function of the cilia leads to mucus plugging and recurrent infections The immunological dysfunction in CF means an inability to fight infection (Figure 8), leading to colonisation to bacteria; most commonly Staphylococcus aureus, Haemophilus influenzae, Pseudomonas aeruginosa and Burkholderia cepacia.



The viscous cycle of recurrent infection (bacterial and viral), hyper-secretion of mucus and resulting inflammation means the lung architecture is destroyed.

Figure 8. Clinical features of cystic fibrosis.

Adapted from Dinwiddie (1998).

Upper Respiratory Tract

Nasal polyps are fairly common in CF and are probably related to chronic sinus infection. They can be removed if troublesome for the patient or causing significant nasal obstruction.

Lower Respiratory Tract

The lungs appear normal at birth and there is ongoing debate as the whether infection or inflammation occurs first and leads to the initial pulmonary insult.

As a result of infection and with progression of the disease bronchiolitis, bronchitis, bronchiolectasis, bronchiectasis and pneumonia and abscess formation occurs (Figure 9).

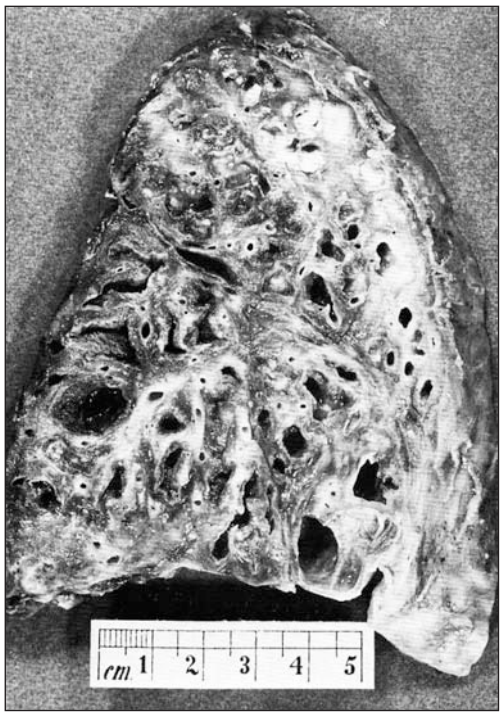


Figure 9. The lung removed on autopsy from a patient with cystic fibrosis showing extensive bronchiectasis and changes as described above.

Adapted from Phelan (1982).

The inflammatory changes that occur obstruct the small airways and lead to destruction of the bronchial walls, dilation of the airways, hyperinflation and areas of collapse. The alveoli are dilated due to air trapping but may also collapse. Spontaneous pneumothorax and haemoptysis are complications of severe pulmonary involvement.

Lung function tests reflect the pathological process (Figure 10). Initially the small airways are involved and therefore sensitive tests that measure these changes are essential.

Figure 10. Progressive changes in lung function in cystic fibrosis.

Adapted from Hodson (1983)

Table 1. Progressive changes in lung function in cystic fibrosis*

Early abnormalities: small airway obstruction
↑ Slope of phase III N_2 washout curve
↓ Response of maximal flow low in VC to helium–oxygen (V isoV̇)
↓ *Pao*$_2$; widened $AaDo_2$ gradient
↑ Physiological deadspace
↑ RV/TLC
↓ Maximum flows low in VC

Late abnormalities: large and small airway dysfunction
↓ MMEFR
↑ Airway resistance
↓ FEV_1, FEV_1/FVC
↓ VC
↓ PEFR
↓ TLC
↑ Anatomical deadspace
Loss of elastic recoil
↑ *Paco*$_2$

Static lung volumes

Total lung capacity (TLC) remains normal until extensive progression of the disease when it is reduced due to fibrosis (Figure 11).

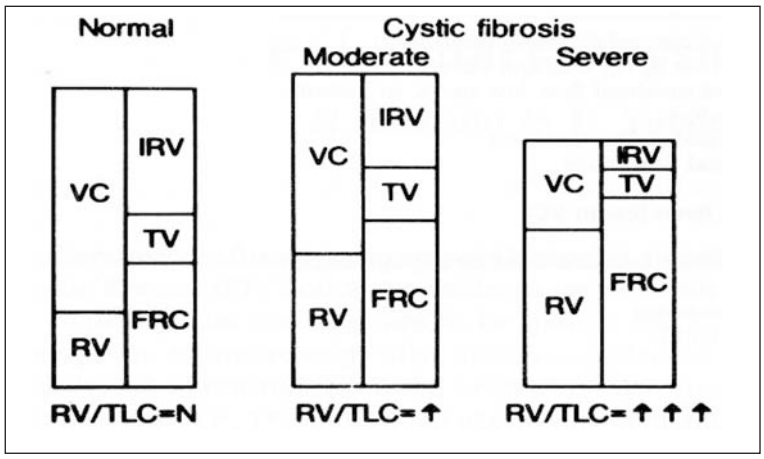


Figure 11. Change in lung volume in CF

Adapted from Hodson (1983)

Residual volume (RV) increases in mild to moderate disease due to air trapping and loss of elastic recoil, which leads to a decrease in vital capacity. An abnormality in the RV/TLC ratio is seen and correlates well with disease severity.

With disease progression a difference is seen in functional residual capacity (FRC) measured by helium dilution (FRCHe) and whole body plethysmography (FRCpleth), where FRCpleth is higher and indicates gas trapping and hyperinflation.

Dynamic lung volumes

Spirometry is most commonly used test to monitor CF in the clinical setting, although changes in the forced expiratory volume in one second (FEV_1) and the ratio of FEV_1 to forced vital capacity (FVC) are poor indicators in mild to moderate disease, although tracking changes in these parameters over time is invaluable. As the disease progresses FEV_1 and FEV_1/FVC ratio decline, with FEV_1 declining more rapidly than FVC.

A reduction in maximum midexpiratory flow rates (MMEFR or $FEF_{25-75\%}$) more closely correlate with disease severity and appear to be a more sensitive indicator than FEV_1 in detecting small airway obstruction. In advancing disease the flow volume curve has a concave shape, which is typical in obstructive disease (Figure. 12).

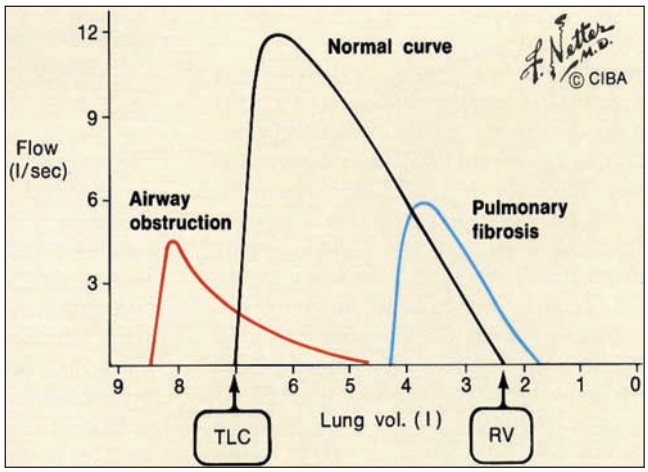


Figure 12. Example of flow volume curves which show typical curves for obstruction, normal and restrictive patients related to lung volume

Adapted from Altose (1979)

These decreases in FEV_1 and FEF_{25-75}, may or may not respond to bronchodilators. The airflow obstruction that occurs in CF is sometimes reversible in up to 50% of patients and they are found to have bronchial hyper responsiveness, which generally reflects the severity of the disease and not the presence of co-existing asthma.

Measures of peak expiratory flow rate (PEFR) are not routinely used in CF as it is too insensitive in detecting changes.

Malnutrition can lead to respiratory muscle weakness and therefore the patient may not be able to perform spirometry maximally as it is partially dependent on muscle strength.

Carbon Monoxide Transfer Factor (TL_{co})

Studies performed by Lamarre (1972) showing hypoxemia and an increase in physiological dead space, suggest that the obstruction in the peripheral airways impinges on the distribution of ventilation and lead to the mis-match in ventilation and perfusion and that tests measuring abnormalities in gas exchange, detected changes before routine conventional tests.

TL_{co} becomes impaired in CF and relates to disease severity, as it remains normal in mild to moderate disease. This relates to the reduced FEV_1 and airflow limitation that occurs, which also leads to desaturation on exercise; which possibly reflects the mis-match of ventilation and perfusion and an increase in physiological dead space rather than a problem with diffusion, although this cannot be excluded.

As CF is not normally associated with destruction of the alveoli, TLco may mildly decrease (if simultaneously measured with V_A), this again is related to ventilation – perfusion mis-matches. The Kco is normal or slightly raised.

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