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A study comparing ultrasound versus X-rays to diagnose paralysed diaphragm muscles

Submission date
14/09/2021

Recruitment status
No longer recruiting

Registration date
28/10/2021

Overall study status
Completed

Last Edited
28/10/2021

Condition category
Musculoskeletal Diseases

[ ] Prospectively registered
[ ] Protocol
[ ] Statistical analysis plan
[ ] Results
[ ] Individual participant data
[ ] Record updated in last year

Plain English summary of protocol

Background and study aims
The diaphragm is the main muscle of breathing. Damage to this muscle, or the nerves supplying it, may cause serious symptoms, such as breathlessness, or a reduced ability to exercise. This condition is known as diaphragm paralysis. Damage to the diaphragm muscle may be visible on a chest X-ray. It usually occurs on one side of the chest. This usually appears as a raised diaphragm one side of the chest compared to the other. However, other conditions may present with a raised diaphragm, so to confirm that the diaphragm is paralysed, further testing is needed.

This further testing usually consists of an investigation that shows the diaphragm in motion, such as ultrasound, or a type of X-ray known as fluoroscopy. Both use a 'sniff test'. This is so called because the diaphragm is not only the main muscle of breathing, but also of sniffing. But while other muscles (such as the rib muscles) contribute to breathing, almost all of a sniff comes from the diaphragm. During fluoroscopy or ultrasound, you are asked to take a series of sniffs, to see how the diaphragm moves on its own. The name 'sniff test' comes from this.

However, ultrasound can be difficult to reproduce accurately, and few clinicians are trained in its use. Fluoroscopy requires a relatively high radiation dose, produces very narrow images of the chest, is time consuming to set up, and is not available in all centres.
As well as X-ray imaging, other breathing tests are then done. This test is known as spirometry. During spirometry, you are asked to take a deep breath in, and blow into a plastic tube as hard as you can. You will be asked to do this once whilst sitting up, and then once again whilst lying down. This test measures the flow of air in the lungs. It is done to confirm if the lungs are unable to inflate properly when lying flat.

Dynamic chest radiography (or DCR for short) is a new X-ray technique that uses a lower dose of radiation than fluoroscopy, and generates large, detailed images of the chest in motion. Computer software can track the diaphragm. From this, it can calculate the speed and direction that the diaphragm moves in. It can also work out the volume of air in the lungs. This can be done quickly and easily, almost in the same time as a standard chest X-ray, and in a standard X-ray room. These features may make it a useful tool to look at conditions such as diaphragm paralysis.

This study is to assess the ability of DCR to diagnose diaphragm paralysis, and compares it to ultrasound.
The study will also look at whether DCR can calculate volumes of air like spirometry can.
The study will also include some DCR images taken at a lower overall radiation dose than standard DCR. While 'standard dose' DCR images are of good quality, it is not yet clear if these low-dose images are of good enough quality to use in day-to-day practice, and this study will investigate if the lower radiation images are good enough for this purpose.

Who can participate?
If you are referred to the Liverpool Heart and Chest Hospital with suspected diaphragm paralysis, you may be asked to take part in this study.

What does the study involve?
This study will not interfere with your standard care, since DCR is already in routine use at our hospital. No changes will be made to how your diagnosis is made, or how you are treated by your doctors.
You may be asked back to Liverpool Heart and Chest Hospital for a further visit, to get some more tests done. This part would be in addition to your standard care. If you are invited to attend the hospital, we will reimburse you for reasonable transport expenses. If you need transport to get to and from the hospital, we can arrange this for you.
The entire process of DCR, spirometry and ultrasound should take under an hour. On the day, we will also record some standard information about you from our notes, such as weight and height. We will also ask you to fill out a questionnaire about your experiences having a DCR.

What are the possible benefits and risks of participating?
We hope that the results of this study will provide evidence that will improve our understanding of diaphragm paralysis. That understanding might one day provide a faster, lower-radiation alternative to fluoroscopy in making the diagnosis of diaphragm paralysis. Your regular care will not be altered by taking part.

If you take part in this study, you will have either one or two dynamic chest X-rays (DCR). The first dynamic chest X-ray is part of your standard clinical care, so would be done regardless of your participation in this study. The second, low-dose dynamic chest X-ray would be extra to the one that you would have if you did not take part.
DCR uses ionising radiation to form images of your body and provide your doctor with clinical information. Ionising radiation may cause cancer many years or decades after the exposure. We are all at risk of developing cancer during our lifetime. 50% of the population is likely to develop one of the many forms of cancer at some stage during our lifetime. Taking part in this study will add only a very small chance of this happening to you. The risk of developing cancer from having a dynamic chest X-ray is 0.001%, which is low. If you have a second, low-dose DCR the is risk is 0.002%, which is low.

Where is the study run from?
The study is run from the Liverpool Heart and Chest Hospital (UK)

When is the study starting and how long is it expected to run for?
August 2021 to August 2023

Who is funding the study?
The study is funded by the Liverpool Heart and Chest Hospital (UK). The X-ray machine is being provided by Konica Minolta, Inc., the manufacturers of the machine.

Who is the main contact?
Dr Thomas FitzMaurice, thomas.fitzmaurice@lhch.nhs.uk

Contact information

Type(s)
Public

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Additional identifiers

Integrated Research Application System (IRAS)
301038

Protocol serial number
1348

Study information

Scientific Title
Sniff test Protocols: comparing Ultrasound to Dynamic Diaphragm Screening: a diagnostic tool for diaphragm paralysis

Acronym
SPUDDS

Study objectives
Null hypothesis: dynamic chest X-ray (DCR) and ultrasound (USS) do not correlate in the measurement of diaphragm excursion, speed and time, during: deep breathing, tidal breathing or voluntary sniffing. The visual appearances of dynamic chest X-rays are not consistent with a positive sniff test on ultrasound and/or an forced vital capacity drop measured on lying/standing spirometry.

Ethics approval required
Old ethics approval format

Ethics approval(s)
Approved 23/09/2021, Health Research Authority, Skipton House, 80 London Road, London, SE1 6LH, UK; +44 (0)20 7972 2545; hra.approval@nhs.net), ref: 21/NW/0251

Primary study design
Observational

Study design
Single-centre longitudinal observational study

Study type(s)
Diagnostic

Health condition(s) or problem(s) studied
Diaphragm palsy

Interventions
Examinations (DCR, USS, spirometry) will be completed on the same day where possible, with all investigations performed all at the LHCH site. An interval of up to 48 hours will be considered allowable as a difference in event acquisition. A questionnaire on patient experiences of DCR will be provided to patients after completion of the examinations, to be filled in at the time.
Dynamic chest radiographs will be acquired using the dynamic chest X-ray equipment at Liverpool Heart and Chest Hospital. The patient is to be positioned in a posterior-anterior position. The frame rate for those participants undergoing routine clinical imaging will be set at 15 frames per second (fps), the standard frame rate used clinically. The investigators will also recruit some individuals in whom DCR has previously been acquired, and a diagnosis of diaphragm palsy has already been made. For those invited to return for repeat imaging (that is, in whom the radiation exposure is in addition to clinical care, and not being used primarily for diagnostic purposes) the frame rate will be set at 6fps. Breathing instructions are called out according to a pro forma: breathe normally, take three sequential sniff breaths, breathe in deeply, breathe out, breathe normally. The image capture is stopped once the breathing cycle is complete or if the 300-frame limit is reached, whichever comes first.
Ultrasound will be performed using a Siemens Acuson X700 machine. Subjects will be placed in a sitting position, with the examiner performing the ultrasound using the methods described by

Boussuges et al. The probe will be placed subcostally (either left or right) between the midclavicular and anterior axillary lines, directed cranially, dorsally and medially. Movement of the mid-hemidiaphragm will be observed by M-mode during tidal breathing, deep breathing and voluntary sniff manoeuvres.
Spirometry will be performed using Geratherm® Spirostik™ spirometers. Subjects will be placed in the upright seated position and spirometric manouevres performed a minimum of 3 times in accordance with ERS/ATS criteria, immediately followed by a minimum of 3 tests in a supine position, to obtain measurement of FEV1, FVC, FEV¬1/FVC ratio, and change in FVC between lying/standing.

Intervention Type
Device

Phase
Not Applicable

Primary outcome(s)
Diaphragm distance (excursion) and speed are measured by both DCR and ultrasound during sniff manoeuvres

Key secondary outcome(s)
1. The postural change in FVC detected on lying/standing spirometry and the lung volumes calculated by DCR.
2. Comparison between diaphragm excursion/speed between 15 and 6 frame per second DCR.

Completion date
01/08/2023

Eligibility

Key inclusion criteria
1. Age >= 18 years
2. Suspected of having a paralysed hemidiaphragm based on suspicious clinical/radiological signs
3. Able to provide informed consent

Participant type(s)
Patient

Healthy volunteers allowed
No

Age group
Adult

Lower age limit
18 Years

Sex
All

Key exclusion criteria
1. Potentially pregnant or lactating
2. Refusal or inability to provide informed consent
3. Unable or unwilling to sit or stand to perform DCR in the radiology department
4. Unable or unwilling to follow breathing instructions (for example, holding their breath)
5. Unable to perform reproducible spirometry and/or full pulmonary function studies within ATS-ERS criteria
6. Any serious or active medical or psychiatric illness, which in the opinion of the investigators, would interfere with subject treatment, assessment, or compliance with the protocol
7. Involved, either currently or recently, in other studies involving non-routine exposure to sources of ionising radiation

Date of first enrolment
04/10/2021

Date of final enrolment
01/10/2022

Locations

Countries of recruitment
United Kingdom

England

Study participating centre
Liverpool Heart and Chest Hospital
Research Unit
Liverpool Heart and Chest Hospital NHS Foundation Trust
Thomas Drive
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L14 3PE

Sponsor information

Organisation
Liverpool Heart and Chest Hospital

ROR
https://ror.org/000849h34

Funder(s)

Funder type
Hospital/treatment centre

Funder Name
Liverpool Heart and Chest Hospital NHS Foundation Trust

Results and Publications

Individual participant data (IPD) sharing plan
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.
Name and email: Thomas FitzMaurice, thomas.fitzmaurice@lhch.nhs.uk
Type of data: processed DCR and ultrasound/spirometry results. Raw images will not be available
When the data will become available: once study is published
By what access criteria data will be shared including with whom, for what types of analyses, and by what mechanism: by request to via the Liverpool Heart and Chest Hospital research department and information governance teams, for the purposes of validation or future similar research
Whether consent from participants was obtained: yes ,this is included in the informed consent form
Comments on data anonymisation, any ethical or legal restrictions, any other comments: only anonymised data will be shared (hence the exclusion of imaging)

IPD sharing plan summary
Available on request

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
HRA research summary			28/06/2023	No	No