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Early View

Research letter

Standard pleural interventions are not high-risk aerosol generating procedures

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Standard pleural interventions are not high-risk aerosol generating procedures.

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Take home message: Percutaneous pleural procedures should not be considered aerosol generating. We hope this study informs future iterations of guidelines on the appropriate use of PPE when performing these procedures.

The nosocomial spread of SARS-CoV-2 has focused attention on the risk of aerosol generating procedures (AGPs) in healthcare[1]. SARS-CoV-2 has been isolated from pleural fluid which has the potential to infect staff or patients if viraemic fluid is aerosolised during procedures[2, 3]. However, evidence for aerosol generation from pleural procedures is very limited. Current guidelines for appropriate use of personal protective equipment (PPE) while performing pleural procedures are based on expert opinion and application of the precautionary principle[4]. We set out to quantify if pleural procedures generated appreciable aerosol (aerosolised liquid particles that have the potential to carry virus) compared to aerosol sampled during normal respiratory activities of breathing and coughing.

This study was performed as part of the AERATOR study assessing the risk of aerosolised transmission of SARS-CoV-2 in healthcare. Ethical approval was granted by North-West Research Ethics Committee (Ref:20/NW/0393).

Aerosol number concentrations were recorded simultaneously using two devices: an Optical Particle Sizer (OPS, TSI Inc. model 3330, USA, sampling flow rate 1L.min-1, samples 0.3-10µm diameter particles with a sampling period set as 1s) and an Aerodynamic Particle Sizer (APS, TSI Inc. model 3330, USA, sampling flow rate 1L.min-1, sheath flow 4L.min-1, samples 0.5-20µm diameter particles with a sampling period set as 1s), see Figure 1A. Technical specifications are detailed in a previous publication, with aerosol sampled through a funnel 10cm from the operating site[5]. Particle losses through impaction in this funnel and tubing setup has been shown in previous work to have minimal effect on the aerosol sampling efficiency [6]. Aerosol generated by an AGP can be measured close to a source or at some remote distance. We measured as close to the source as pragmatically possible to ensure accurate quantification of aerosol concentrations generated by the procedure[7].

To reduce the background aerosol concentration all procedures were performed in an ultra-clean laminar flow operating theatre (EXFLOW 32, Howarth Air Technology, UK) with high efficiency particulate air (HEPA) filtration and air supply rate of $1200 m^3.s^{-1}$ (550-650 air changes/hr). In this environment, the background aerosol number concentration is $0 cm^{-3}$, allowing clear attribution of detected aerosol to specific manoeuvres. The air flow is $0.2 m.s^{-1}$ at 1m above the floor below the laminar flow. To demonstrate that this airflow does not affect the sampling efficiency of aerosol generated under the laminar flow, the aerosol generated by voluntary coughing and breathing was sampled in the same position, 10 cm from a subject's face. Both the peak aerosol concentration and the mean aerosol concentration produced during the pleural procedure were compared to aerosol produced when the patient coughed or spoke, respectively.

Given the different pleural procedures have common themes, the procedures were sub-classified into 5 different elements and the aerosol generated by each assessed. All procedures were performed with patient sitting up apart from thoracoscopy which was performed in the lateral position.

- Pleural anaesthesia; when local anaesthetic was distilled subcutaneously and down to the pleura including the aspiration of a small amount of pleural fluid, equivalent to a diagnostic 'pleural tap'.
- Therapeutic Thoracentesis; where a larger volume of fluid is aspirated from the pleural space (equivalent to a therapeutic aspiration).
- Chest drain insertion; including indwelling pleural catheter (IPC) and surgical chest drain insertion.
- Open pleural space procedures; during thoracoscopy with a port in situ allowing the movement of air between the pleural space and the atmosphere.
- Chest drain removal.

We also measured any aerosol produced from fluid management systems of;

- Underwater seal chest drain bottle (Rocket Medical)
- IPC bottle aspiration (BD)
- Thopaz+ Digital Chest Drainage System (Medela)

Ten patients (who were SARS-CoV-2 PCR negative) requiring pleural procedures (3 medical thoracoscopies, 3 indwelling pleural catheter insertions (15.5Fr), 1 therapeutic aspiration (6Fr), 3 indwelling pleural catheter removals)) were recruited to the study, with 2 further patients with chest tubes already in-situ for pneumothorax with ongoing air leak. The majority of patients were male (10/12) with a median age of 76 (IQR 72-79).

Figure 1B (logarithmic Y axis) shows the peak aerosol number concentration sampled during each procedure compared to peak number concentrations from coughing and mean number concentrations from breathing. For most procedures, the peak number concentration was of similar magnitude to or less than the mean aerosol number concentration measured during breathing from the same patients or from healthy volunteers from a previous study and was significantly less than the peak number concentration detected from a cough [5]. The mean concentration for all procedures is typically much less (up to two orders of magnitude)

smaller than the mean concentration sampled when a subject is breathing. Again, it should be stressed that breathing is a sustained activity while coughs and these clinical interventions lead to transient events.

Figure 1C illustrates the difference between the particle number concentration sampled during a single procedure compared to breathing or coughing for a patient undergoing a medical thoracoscopy.

This study shows that percutaneous instrumentation of the pleura does not result in significant aerosol generation. Total aerosol generation during these procedures was significantly below the number concentration produced by breathing or coughing.

Current British Thoracic Society (BTS) guidelines recommend that “closed pleural procedures such as pleural aspirations and chest drain insertion can be undertaken in Level 1 PPE (surgical mask and visor, as well as gown and gloves)” whereas “open procedures such as thoracoscopy and IPC insertion, where pleural fluid may splash, should still be considered AGP [4]. Therefore, Level 2 PPE should be worn (FFP3 mask, long sleeved gown, gloves, eye protection)”. On the basis of this evidence, pleural procedures are not aerosol generating and additional PPE (above that indicated for routine patient care) is not required, although eye protection should be worn given the risk of splash.

It is well recognised that pleural procedures, especially those that generate a negative intrathoracic pressure (e.g. therapeutic thoracentesis) can induce a cough in participants. We would therefore recommend the patient be asked to wear a surgical facemask, which has been shown to significantly reduce aerosol produced during cough[5].

Pleural fluid management systems such as underwater seal chest tube bottles have also been seen as a source of aerosol generation with several studies advocating the use of antiviral filters. Duffy and colleagues assessed aerosol generation by bubbling air at different rates through an underwater seal bottle, sampling a maximum aerosol concentration of particles (within the same size range to those studied here, 0.3–10µm) during the bubbling process of ~4100ft^{-3}, caused by atomization of the water[8]. This equates to a peak number concentration of ~0.14cm^{-3}, which is similar to the peak concentrations that we observed during the fluctuations of sampled aerosol number concentration during pleural procedures. We show that the peak number concentration sampled during the pleural procedures was similar to that sampled during the background measurement, orders of magnitude smaller than that sampled during a cough and was never greater than the mean number concentration sampled during a period of quiet breathing. However, given our sample size

for underwater seal bottles is small (n=3) and the mitigating factors are simple we feel guidance should still encourage the use of viral filters or Thopaz devices until further evidence is gathered, especially in pneumothoraces with high air leaks.

In summary, using two methodologies to measure aerosol emission with no background aerosol interference, this study has shown that percutaneous pleural procedures are non-aerosol generating. We hope this will inform future iterations of guidelines on the appropriate use of PPE when performing these procedures.

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Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributorship statement

DTA, FWH and NAM developed the study idea. FKAG, FWH, JWD, BRB and JPR developed the sampling design. DTA, SS, FWH, HW, AD, GN, NAM collected the primary aerosol data. FKAG, SS, BRB and JPR analysed the aerosol data. All authors were involved in the writing of the manuscript.

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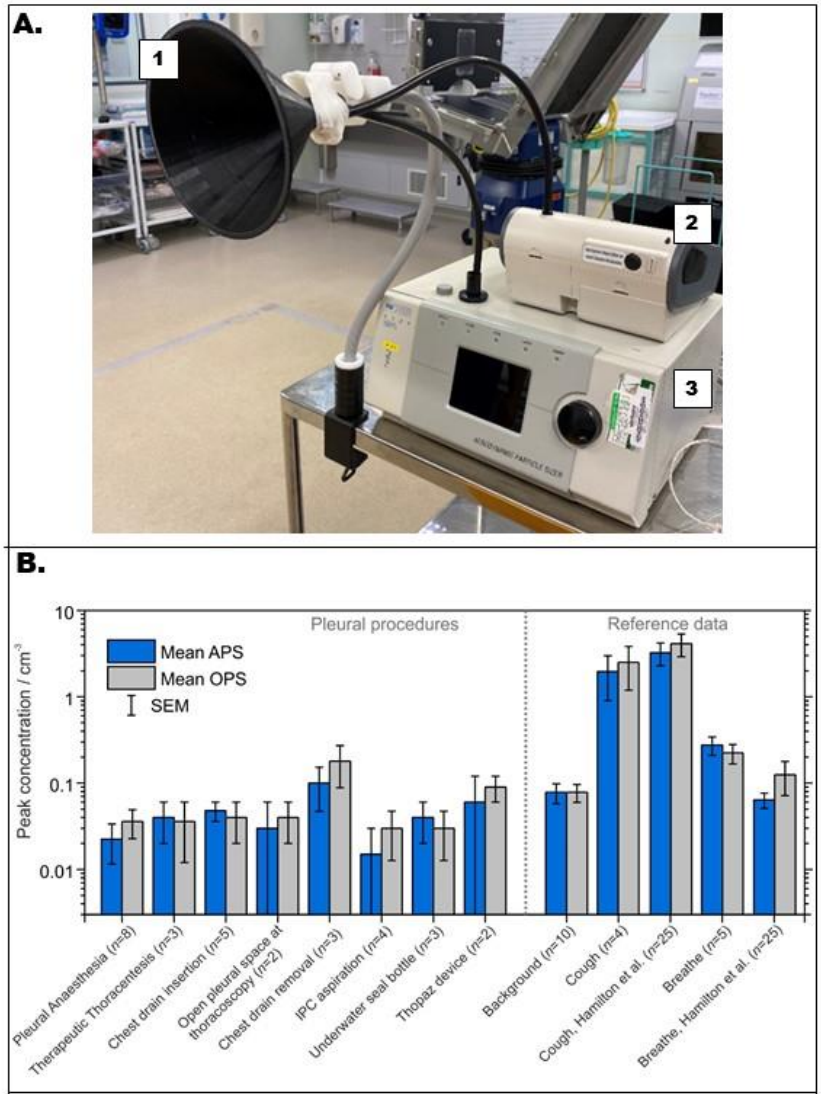

1. Sampling Funnel, 2. OPS (Optical Particle Sizer), 3. APS (Aerodynamic Particle Sizer)
SEM: Standard error of the mean.

Figure 1: A. Sampling equipment set-up. B. Bar chart (log-scale) showing the peak aerosol number concentration sampled by the APS and OPS methods during different procedural elements compared to mean aerosol number concentrations measured during breathing and peak aerosol number concentrations measured during cough. C. Particle concentration over time (linear scale) during a single thoracoscopy compared to aerosol production from the patient breathing and coughing pre-procedure. Pre-procedure aerosol concentrations are compared to that from healthy subjects in Hamilton et al. 2021[5].