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COVID-19 Safety: aerosol generating procedures and cardiothoracic surgery and anaesthesia

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A Statement from the Australian and New Zealand Society of Cardiac and Thoracic Surgeons (ANZCTS) and Anaesthetic Continuing Education (ACE) Cardiac Thoracic Vascular and Perfusion Special Interest Group (CTVP SIG).

Abstract

Introduction
COVID-19 emerged in Wuhan, China in late 2019 and the World Health Organisation (WHO) declared a global health emergency on 31st January 2020. Currently around 10-15% of those affected develop severe disease and worldwide mortality is around 6% (1). Healthcare workers are at risk of infection from aerosolisation of respiratory secretions, droplet and contact spread. There are a number of procedures that represent a high risk of aerosol generation (AG) during cardiothoracic surgery. It is important that adequate training, equipment and procedures are in place to reduce that risk.

Recommendations
This statement reflects recommendations based on expert opinion, national guidelines, and available evidence. Our knowledge with regard to COVID-19 continues to evolve and with this, guidance may change and develop. Our colleagues are urged to follow national guidelines and institutional recommendations regarding best practices to protect their patients and themselves.

Changes in Management
There are a number of key recommendations, which reduce the risk of AG during cardiothoracic surgery and these are summarised in Box 1. Controversies exist with regard to the management of low-risk patients undergoing procedures, which are at high risk of AG, and recommendations for these patients will change depending on the regional prevalence, risk of community transmission and the potential for asymptomatic patients attending for these procedures.

These recommendations are endorsed by the Australian and New Zealand Society of Cardiac and Thoracic Surgeons (ANZCTS) and Anaesthetic Continuing Education (ACE) Cardiac Thoracic Vascular and Perfusion Special Interest Group (CTVP SIG).

Background
COVID-19 is a contagious disease that is caused by the coronavirus SARS-CoV-2. Transmission of the virus in the community is primarily by contact with droplets, fomites and to a lesser degree aerosol generation (AG) (2). For healthcare workers AG during airway management is a significant concern. In cardiothoracic surgery there are particular procedures that are high risk for AG and hence, transmission of COVID-19. In order to protect staff, it is important to minimise these procedures if possible, or ensure that they are conducted in a suitable environment with appropriate personal protective equipment (PPE). While screening tools are available to assess the risk of a patient having COVID-19, transmission can occur from asymptomatic patients, albeit at low risk. The Royal Australasian College of Surgeons (RACS) has published guidelines for the management of surgical patients during the COVID-19 pandemic (3). This document discusses issues specific to cardiothoracic surgery.
Methods

A survey amongst the ACE CTVP SIG committee conducted on the 12th April 2020 revealed wide variability in the management of cardiothoracic surgical patients during the COVID-19 pandemic. Following discussions with the ANZSCTS committee, it was felt that despite recommendations regarding AG in airway management and ventilation, there was limited information and guidance for the management of AG during cardiothoracic surgery and the potential for prolonged and ongoing AG during these procedures. A need for guidance in this sub-specialty group during the COVID-19 pandemic was identified.

A panel of 6 experts, 3 cardiothoracic anaesthetists and 3 cardiothoracic surgeons, were assembled from different states and hospitals across Australia to review national guidance, consensus recommendations and current literature on AG relevant to cardiothoracic surgery and the management of patients during the COVID-19, Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) outbreaks.

Articles reviewed, were of low or very low quality evidence according to Grading of Recommendations, Assessment, Development and Evaluation (GRADE) criteria, consisting mainly observational data and expert opinion. Recommendations were based on the principles outlined in these publications combined with expert opinion and experience in the sub-specialty of cardiothoracic surgery.

Our recommendations were then referred to the ACE CTVP SIG and ANZSCTS executive committees, consisting cardiothoracic anaesthetists and surgeons from across Australia and New Zealand for review and comment.

The authors acknowledge that as evidence and knowledge with regard to COVID-19 continues to evolve, guidance may change and develop.

Recommendations

Personal Protective Equipment (PPE)

Guidelines regarding PPE have been produced by individual state government health authorities e.g. Clinical Excellence Commission, New South Wales and the Department of Health and Human Services, Victoria in response to the COVID-19 outbreak (4,5).

PPE type is classified as standard, contact, droplet or airborne precautions. Formal training is essential and donning and doffing procedures should be strictly adhered to. N95/P2 masks should be fit-tested and fit-checked each time they are applied (6). The most effective protection is frequent and effective hand hygiene(7).

Risk Stratification

Risk stratification is paramount in patients presenting for cardiothoracic surgery. The definitions for confirmed and suspected cases can be found in the latest Department of Health Series of National Guidelines (SoNG) (8)

High-risk patients include:

- Patients with confirmed COVID-19 infection
- Symptomatic patients without a negative swab or clearance from an infectious disease specialist or department

- Asymptomatic patients with epidemiological risk factors
- Unconscious patients unable to provide risk screening information – specifically patients presenting with trauma and out of hospital cardiac arrest.

Performing routine swab PCR testing of all patients planned for cardiothoracic surgery is debatable. Interpreting the result of a test for COVID-19 depends on the accuracy of the test and the pre-test probability of disease. It may allow positive patients to be identified and timing of surgery to be reconsidered as a positive RT-PCR test has more weight than a negative test because of the test's high specificity but moderate sensitivity (9). A single negative test, however, should not be used as a rule-out in patients with strongly suggestive symptoms. A systematic review of the accuracy of COVID-19 tests reported false negative rates of between 2% and 29% (10)

Currently risk stratification according to the patient's clinical circumstances and local COVID-19 epidemiology is the most appropriate strategy.

Scheduling of Cardiothoracic Surgery Cases

The majority of cardiothoracic surgical cases are performed for prognostic reasons. The timing of these procedures will depend on a balance between the benefit to the patient, the risk to the patient of being infected with COVID-19, resource availability and local government restrictions.

As COVID-19 patients can present with both cardiac and respiratory symptoms, it is vital that patients are appropriately screened and a differential diagnosis of COVID-19 illness is considered. It is recommended by RACS that COVID-19 positive or suspected patients be managed conservatively, if possible, with their surgery delayed (3). If emergency surgery is required then patients should be risk assessed. It should be remembered that acute coronary syndrome is a common cardiac manifestation of COVID-19 (11). There is a joint paper from ANZSCTS and the Cardiac Society of Australia and New Zealand on the management of these patients (11)

Data on the risk of COVID-19 positive patients undergoing cardiothoracic surgery is limited. Anecdotal reports suggest a high peri-operative mortality risk. A study from Wuhan in patients undergoing non-cardiac elective surgery during the incubation period of COVID-19 demonstrated a 44% ICU requirement and 20% mortality (12).

Mechanics of Aerosols and SARS-CoV-2 spread

Most SARS-CoV-2 spread is likely to be direct or indirect (fomite) contact or droplet spread. The World Health Organisation (WHO) indicates that airborne spread may occur but only during AG procedures (2).

Most clinical risk data around aerosol risk of transmission is summarised in a systematic review of SARS-CoV-1 (13), although the 10 studies included were classified by GRADE as 'very low quality evidence'. Procedures presenting an increased risk of transmission included tracheal intubation, non-invasive ventilation, manual ventilation prior to intubation and tracheostomy.

The mechanisms responsible for the generation of aerosolised particles require disruption of the respiratory tract lining fluid surface tension (14). This may be achieved by high shear forces or manual/mechanical disruption such as during lung surgery.

Aerosol Generation and Cardiothoracic Surgery

A number of procedures are at a high risk of AG during cardiothoracic surgery. These include:

- Bag-mask ventilation
- Tracheal intubation
- Tracheal extubation
- Bronchoscopy
- Lung Isolation
- CPAP
- Lung recruitment and reinflation
- Inadvertent Lung Injury/ Air leak/ Bronchopleural Fistula/ Decortication
- Chest Drain Management

The magnitude and spread of SARS-CoV-2 will vary greatly over time and geographical location and, therefore, advice may change with respect to low-risk patients undergoing procedures at high-risk of AG depending on the regional community transmission and the potential for asymptomatic patients attending for procedures.

Thoracic surgery, in particular, has the potential to generate high volumes of prolonged and ongoing AG. As such, in areas or times when risk of community transmission is high, it may be reasonable to adopt airborne precautions for all thoracic patients irrespective of COVID-19 status to protect staff (15).

The guidance on treatment of low-risk patients during high AG procedures should be in keeping with national, regional and institutional policies and with recognition of the requirement to conserve PPE.

Operating Theatre Setup

There should be a designated operating room (OR) to manage COVID-19 patients with a protocol for patient flow to and from the OR (16). Negative (or neutral) pressure rooms are preferred. Dirty and Clean buffer zones should be observed and staff and equipment should be kept to a minimum. Disposable equipment should be used where available and clean runners should be available to provide additional instruments, drugs and equipment.

Team briefings are important. These should aim to introduce the team, discuss the surgery, identify AG procedures and review protocols. Communication may be difficult in PPE and this should be recognised.

Anaesthesia

The peak risk period during cardiac surgical procedures is intubation and extubation. The Safe Airway Society Australia and New Zealand (SAS) have produced guidelines for airway

management in the COVID-19 environment (17). Intubation and extubation processes should follow these accepted guidelines to minimise AG. There should be a wait time, if possible, for the aerosol risk to subside which will be specific to the airflow with a recommendation of 3-5 air changes (approximately 15 minutes) (15). When transferring intubated patients to intensive care post surgery, the number and duration of breathing circuit disconnections should be minimised, with processes to prevent AG as per SAS guidance (17).

Lung Isolation and Single Lung Ventilation

Lung isolation can be achieved by a number of measures. Options include left or right-sided double lumen tubes (DLT), bronchial blockers (BB) or a single lumen tube (SLT) advanced into the non-operative lung (18).

The European Association of Cardiothoracic Anaesthesiology (EACTA) has published recommendations for airway management in thoracic anaesthesia (19). A survey conducted by EACTA revealed the choice of lung isolation management is likely to be influenced by the intubation status of the patient, predicted airway difficulty and individual preference (19).

Many steps involved in the achievement and troubleshooting of lung isolation are high AG procedures. There are a number of adaptations that we suggest be adopted to minimise this. These are described below.

Intubation should be undertaken as per SAS guidance with an experienced thoracic anaesthetist. Clinical assessment of DLT placement can be performed by inspecting and auscultating to ensure bilateral air entry and then sequentially clamping the tracheal and bronchial arms without disconnection. This may avoid the need for bronchoscopy.

Another option is to confirm lung ventilation with ultrasound, looking for lung sliding (ventilation) and absence of lung sliding and lung pulse (no ventilation but no pneumothorax) (20).

If bronchoscopy is required for positioning or troubleshooting, this should be performed with the ventilator disabled, without positive pressure on the circuit and with the patient adequately paralysed to reduce AG.

DLTs with embedded cameras (e.g.Vivasight^{TM}, Ambu) may reduce the requirement for bronchoscopy (21). There will be a learning curve associated with these devices. Although they may reduce the AG risk during placement, they are not a substitute for the wider use of bronchoscopy during thoracic surgery.

Lung isolation requires deflation of the lung. We recommend that viral filters be placed on each limb of the DLT to protect against AG during deflation and any leak of ventilated gas. Paediatric filters may be useful to reduce the weight and kinking of the tube (figure 1). Application of CPAP to the non-ventilated lung, if required, should be performed with the filter in place.

Suctioning of the lung is often required and we recommend using closed in-line suction. This should be inserted with the ventilator disabled and the tube clamped to minimise AG (figure 2). The patient should be adequately paralysed to prevent coughing. Self-sealing suction-safe connectors can also be placed to minimise disconnections and AG.

Air Leak During Thoracic Surgery

Any thoracic surgical procedure where there is presence, or creation of alveolar, parenchymal or broncho-pleural leak should be considered an open airway and high risk for AG. This includes lung resection surgery, decortication and pneumothorax surgery. While many surgeons use lung resection techniques that minimise an open bronchial tree or alveolar leak, this cannot guarantee freedom from AG. Pulmonary decortication is frequently associated with alveolar air leak and should be considered very high risk for AG. Airborne PPE should be employed for these procedures.

Procedural Bronchoscopy

Bronchoscopy is at high risk for AG and should be minimised (17). We recommend all bronchoscopy should be videoscopic with airborne PPE employed. Rigid bronchoscopy is very high risk and should be avoided.

Chest drain management

If virus is present in the pleural space then there is risk of AG at the chest drain exhaust (22). Chest drain insertion, even by careful closed technique, is a risk. When an underwater drain bottle is on suction the risk is minimal, however, if the bottle is open to air then AG risk exists, which will be higher with any air leak. To minimise risk a viral filter can be applied to the exhaust vent (22). Suction can then be connected to the filter exhaust, without creating a risk of open exhaust and AG (figure 3). The resistance of the viral filter up to a flow rate of 30 L/min has been tested and found to be trivial, correlating with clinical experience that the filter does not impede airflow out of the chest (23). It is important, however, that filters be checked and changed daily.

Transoesophageal Echocardiography (TOE)

TOE carries a high risk of AG in an awake or sedated patient due to the risk of coughing or gagging. In an anaesthetised and paralysed patient with a cuffed endotracheal tube the risk is currently unknown, and some regions have determined TOE in intubated patients non AG.

The American and British Societies of Echocardiography, however, consider TOE as an AG procedure regardless of the intubation status (24,25). They both recommend airborne precautions and the most experienced sonographer to perform the TOE.

We recommend that the requirement for TOE be considered on an individual case basis rather than routine utilisation. If necessary, practical interventions to prevent cross-infection can be considered including the use of plastic TOE covers, dedicated COVID-19 equipment, a 2-person technique to manipulate probe and acquire images, a plastic barrier over the patients head during manipulation, and probe removal and decontamination protocols.

Cardiopulmonary Bypass (CPB)

There is some evidence that COVID-19 virus RNA has been found in blood (26). It is also possible for SARS-CoV-2 to cross the membrane and aerosolize through the gas-exit port of the membrane lung during CPB, although the risk is extremely low (26). The Australian and

New Zealand College of Perfusionists have produced a statement on this matter (27). As per existing guidelines, it is recommended that oxygenators be scavenged similarly to anaesthetic ventilators (28).

Inadvertent Lung Injury During Cardiac Surgery

Lung trauma may occur at many stages during cardiac surgery. An open pleural space without air leak is relatively low risk for AG. However, lung injury may occur on opening the pleura, internal thoracic artery harvest and sternal wire placement. Staff conducting cardiac surgery on patients at high risk of COVID-19 should employ airborne PPE. Inadvertent lung injury in patients at low risk for COVID-19 can be managed with standard PPE, with an appropriate protocol in place for visceral pleura breach in times and regions of high community transmission. A suggested approach would be to stop ventilation, pack lung, recommence ventilation at low tidal volume, adopt airborne precautions, temporarily discontinue ventilation, seal air leak and recommence ventilation.

Trainees and Training

Training of junior doctors is always a high priority. Care needs to be taken in the current environment that this is always done with safety in mind. Appropriate case selection and consideration to the duration of operations is important. Procedures that are high risk of AG and spread of COVID-19 are not appropriate cases to be allocated to trainees.

Conclusions

There are a number of procedures that represent a high risk of AG during cardiothoracic surgery. It is important that recommendations are in place to reduce that risk and protect healthcare workers involved in these procedures.

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Box 1

Key Recommendations

- General considerations
    - The COVID-19 pandemic continues to evolve. Patient and staff management principles should be applied in the light of the specific regional and temporal context of the pandemic.
    - Patient Risk stratification is important and may be guided by National DOH Series of national Guidelines.
    - Local prevalence may be used to guide decisions around routine preoperative testing.
    - Most SARS-CoV-2 spread is likely to be contact or droplet related. Aerosol spread is likely to be of lower overall frequency but certain procedures, during thoracic surgery especially, present a high risk of aerosol generation (AG).
    - Conservative management or considered delay, of confirmed or suspected COVID-19 positive patients may benefit patients and healthcare workers.
    - COVID theatre planning should consider theatre airflow, contamination zones, theatre personnel present, additional staff roles, PPE and appropriate staff briefings.
- Procedural Considerations
    - Experienced clinicians in cardiothoracic anaesthesia and surgery should be involved in the operative care of cardiothoracic surgical COVID-19 patients.
    - Aerosols may be highest around intubation, extubation and around open circuits, which are often a part of thoracic anaesthesia. Steps should be taken to minimise required disconnections and/or AG during these periods.
    - The AG risk from TOE may be amplified by coughing and gagging. Considering the risk benefit balance for TOE and practical interventions to reduce risk, is appropriate.
    - AG may also occur with surgical opening of the lungs and surgical trauma. Predefined procedures to respond to such scenarios should be considered and practised.
    - The risk of viral transmission via cardiopulmonary bypass circuit oxygenators is unknown. Scavenging similar to that attached to anaesthetic machines may minimise potential risk.

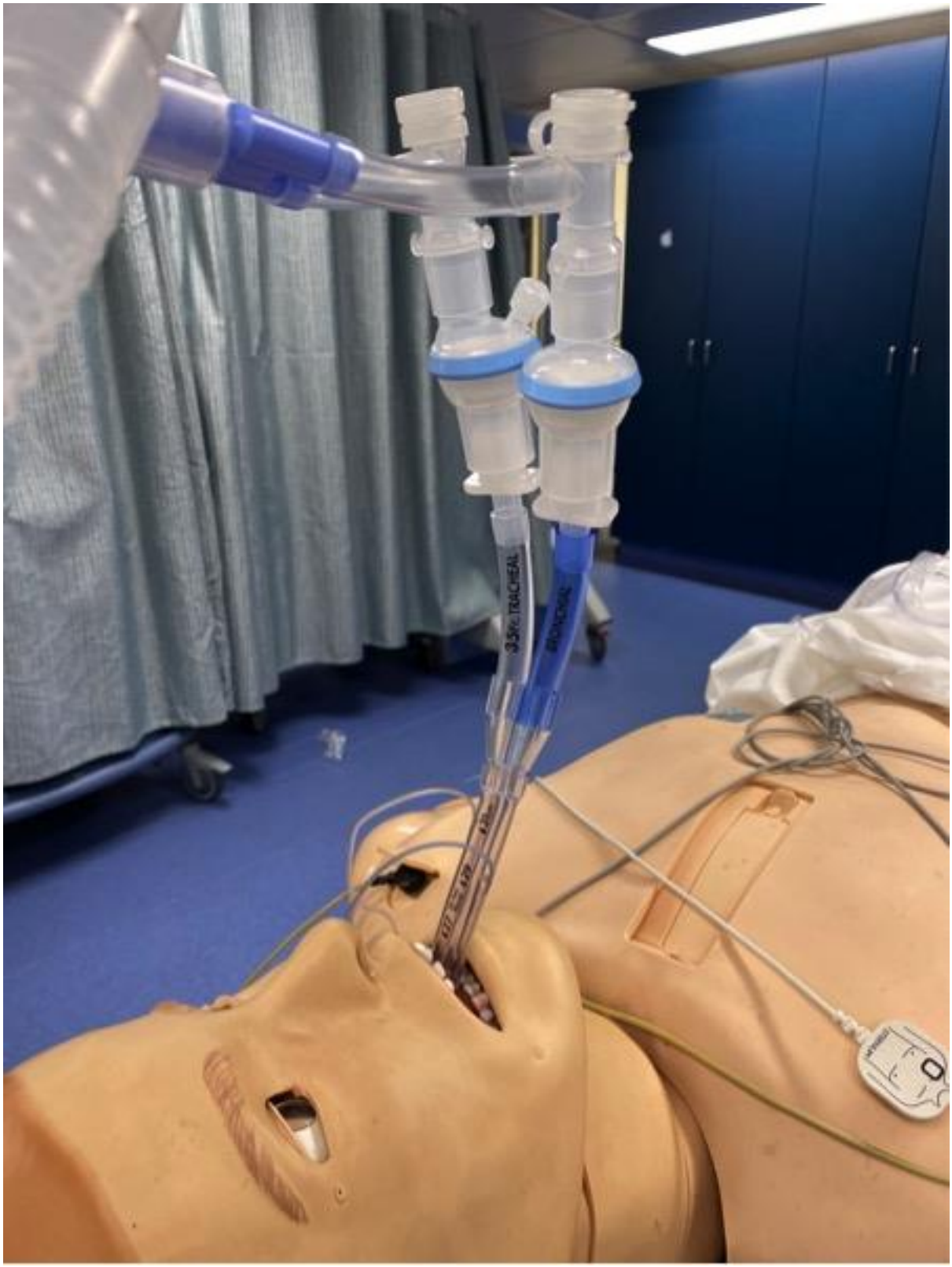

Figure 1 Double lumen tube with paediatric filters in place

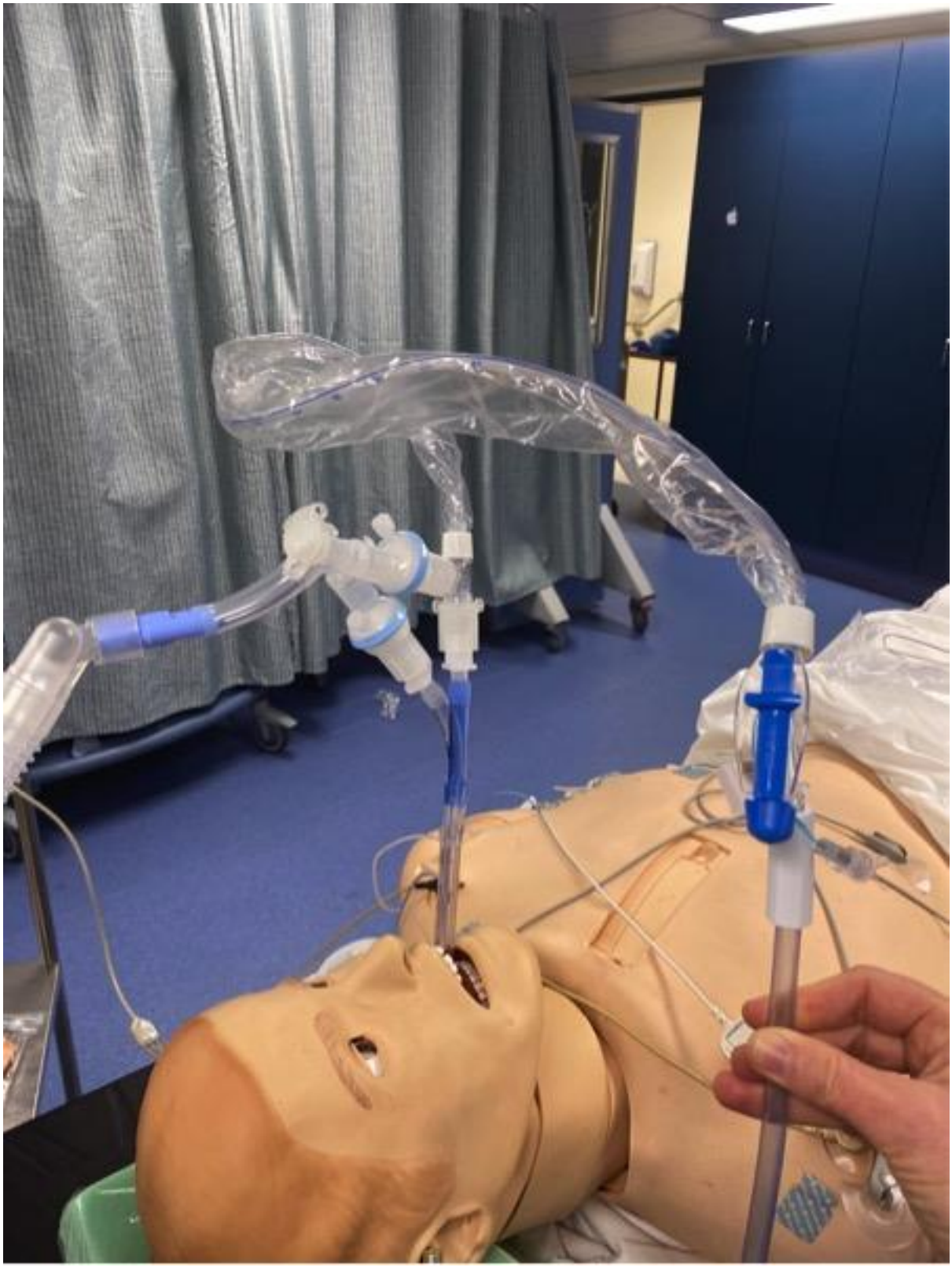

Figure 2 Double lumen tube with in-line suction

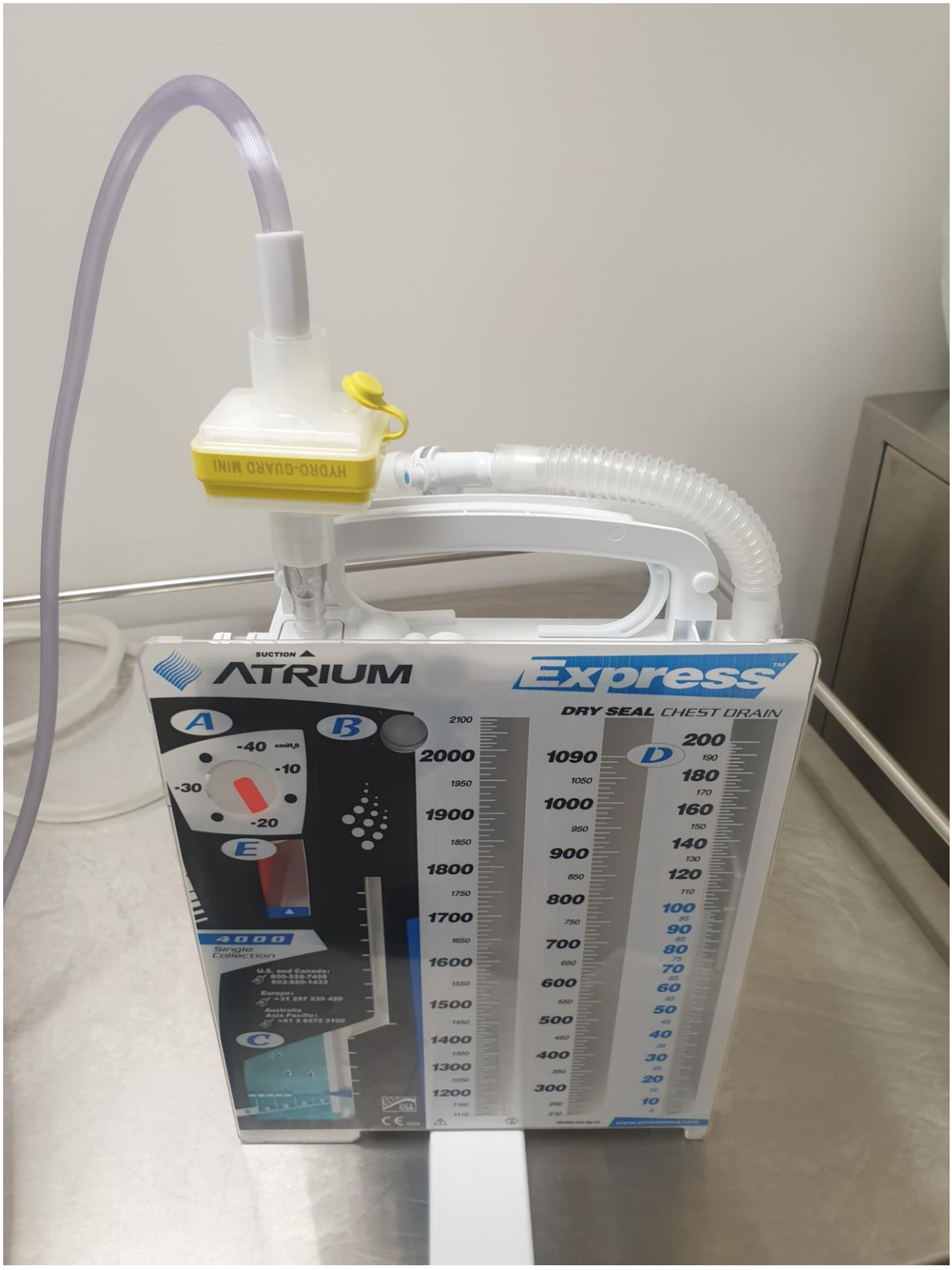

Figure 3 Chest drain with filter on exhaust