“Trach in a Vac”: Negative Pressure Tracheostomy Technique in the COVID-19 Pandemic

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Abstract

During the COVID-19 pandemic it is inevitable there will be many cases requiring tracheostomy in which patient COVID-19 status will be positive or suspected. A simple technique utilising available equipment is urgently required to decrease the risk of healthcare worker infection. If we can create an isolated negative pressure surgical field around the airway then the aerosolised pathogen will be theoretically contained within this and can be evacuated away safely for elimination.

INTRODUCTION

The SARS-CoV-2 virus spreads primarily through upper respiratory tract droplets (salivary, mucous or nasal secretions) expelled via cough, sneeze or speech [1]. The transmission risk is higher, and mode of spread different, in patients undergoing aerosol generating procedures (AGPs), such as tracheostomy. This results in potential for airborne transmission, with smaller droplet nuclei becoming airborne and travelling longer distances away from the patient.

Operating theatre staff appears to be at higher risk of viral exposure and subsequent infection with the death of a number of ENT surgeons having been reported [2]. This is presumed to be due to viral exposure during upper airway examinations and AGPs [3]. Infection through the aerosol route not only seems to increase the likelihood of infection but also may predispose to a more severe course and greater mortality compared to age-matched controls.

There will be many patients requiring tracheostomy during the COVID-19 pandemic in which COVID-19 status will be positive or suspected and simple technique utilising available equipment is urgently required to decrease the risk of healthcare worker infection. If we can create an isolated negative pressure surgical field (NPF) around the airway then the aerosolised pathogen will be theoretically contained within this and evacuated away safely for elimination.

MATERIAL AND METHODS

The procedure was initially developed on a simulation dummy, before being performed by three operating theatre teams. Staff satisfaction was measured by questionnaire. Flow and pressure within the NPF was measured with the TSI 4040F Series Mass Flowmeter.

Technique description

A. Preparation and draping
1. Surgeons wear extra set of sterile gown and gloves
2. Place anaesthesia bars at top of theatre table, top and bottom of mayo table and the top of the theatre table prior to prepping and draping.
3. Drape right angle bars then drape the patient with disposable drapes.
4. Wide preparation and use adhesive drape over entire neck e.g. Opsite/Ioban

B. Open surgery prior to airway entry
1. Standard open tracheostomy until completely ready to enter the airway, meticulous haemostasis.
2. Obtain all instruments and equipment required inside the negative pressure surgical field:
Retractors
Suction tubing and sucker
Forceps for surgeon and assistant
Scissors
Cricoid hook
Tracheal dilator
Diathermy
Sutures
Tracheostomy tube (cuff tested)
Syringe
Tracheostomy inner tube
Surgical site dressings
NPF suction tubing (to smoke evacuator)
* Catheter mount circuit connection e.g. 'elephant’s trunk'
Other equipment as per surgeon preference
* suction tubing (for NPF)
* Sterile plastic box for instruments including sharps

C. NPF draping (Figure 1 and Video link)
Sterile stock used additional to tracheostomy setup:
Medline C-arm covers ("NPF-bag") 105cm x 164cm Ref: DYNJSD1013 (x 1)
Site-rite Probe cover kit ref: 9001CO197 x 3 for right angle bars
Medline drape tape Ref: 3550CA (3 packs of 2) if unavailable use strips of ioban or opsite.
Opsite 45cm x 55cm Ref: 4989 (x 2)
Spare opsite or drape tape for sealing portals.

1. Unfold NPF-bag (under cross bars) with open end directed towards patient feet. Use scissors to cut a 10 by 10cm opening for the surgical site in the underside of NPF-bag (easiest to cut this opening then flip bag over)
2. With assistant holding NPF-bag open, insert Opsite applying it to stick the opening to the opsite already on the surgical field.
3. Via the open end of the NPF-bag, introduce all equipment (except NPF suction, sterile circuit connection, suction and diathermy) and place on mayo table (within NPF-bag)
4. Open out NPF-bag under cross bars and attach it to them using drape tape
5. Make lateral ports for arms. HINT: always make port openings as small as possible so they stretch and are easily sealed by drape tape
6. Make cranial port and insert circuit connection (at chin level) and seal. Anaesthetist can then connect the second anaesthetic circuit tubing (called the ‘post-tracheostomy circuit tubing’)
7. Seal off caudal end of NPF-bag
8. Make small separate caudal ports for NPF suction, surgical suction and diathermy and seal.

D. Establish and test suction of NPF (Figure 2)
1. Attach the negative pressure suction tubing so that the air passes through a HEPA (high efficiency particulate air) filter.
2. Negative pressure is confirmed by seeing indrawing or collapse of the plastic drape. If collapse of the bag is problematic flow can be controlled by the anaesthetist by opening and closing the post-tracheostomy circuit tubing.

E. Airway surgery
1. stop ventilation and anaesthetist advance endotracheal tube so that the cuff is inferior to the surgical site and is not cut
2. perform tracheostomy looking through plastic drape of NPF-bag
3. withdraw endotracheal tube until able to insert tracheostomy tube (AIRFLOW WILL OCCUR IN NPF TOWARDS SUCTION)
4. tracheostomy cuff up and establish closed circuit with tracheostomy (Figure 3)
5. leave NPF suction on whilst securing tracheostomy and applying surgical site dressing

F. Exit of NPF
1. non disposable instruments and safely contained sharps placed in plastic box
2. incise adhesive drapes/ NPF-bag between edge of tracheostomy site and sterile circuit connection to allow careful removal of plastic box (Figure 4)
3. Plastic box removed from sterile field and immersed in soapy water to 10cm in usual lidded-transport tub. In central surgical sterilising department (CSSD) ensure bowel bag is full of hot soapy water (PPE worn by CSSD staff) and after suitable time reprocess with sterilisation protocol.

4. Sterile field resealed with another opsite

5. Surgeons doff extra (outer layer) set of sterile gown and gloves and leave attached to drape. Sealed NPF-bag and drapes with attached gowns disposed of carefully into contaminated waste bag

6. Staff remove under-layer of PPE outside room as usual

7. Usual COVID-19 room operating theatre decontamination at appropriate time.

Staff and Surgeon satisfaction:

(Figure 5)

Negative Pressure and Flow:

Measures of pressure inside the NPF range from -20kPa to -60kPa. When flow is allowed (by opening of post-tracheostomy anaesthetic circuit tubing) the rate of flow is 40L/minute.

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### Figure 2 NPF pre-tracheostomy.

Red: NPF bag; Blue: Anaesthetic tubing; Purple: items traversing NPF bag (suction, diathermy, ‘elephant’s trunk’)

### Figure 3 NPF post-tracheostomy.

Red: NPF bag and adhesive drape component; Light blue: thick-adhesive drape; Thin-sterile surgical drape; Blue: Anaesthetic tubing; Purple: items traversing or in NPF bag (NPF suction, tracheostomy tube, ‘elephant’s trunk’); Green dots = aerosol droplets containing virus or infective agent; Black circles: cross-sections of cross-bars

Note: for simplicity these diagrams do not show the third cross bar or mayo table

### Figure 4 NPF-bag exit cut.

Red: NPF bag and adhesive drape component; Light blue: thick-adhesive drape; Thin-sterile surgical drape; Blue: Anaesthetic tubing; Purple: items traversing NPF bag and post-tracheostomy anaesthetic circuit; Green dots: aerosol droplets containing virus or infective agent; Black circles: cross-sections of cross-bars

### Figure 5 Ease and Efficacy of Trach-in-a-vac procedure

Red: NPF bag and adhesive drape component; Light blue: adhesive drape; Blue: Anaesthetic tubing; Purple: post-tracheostomy anaesthetic circuit; Dotted red line: cut n NPF-bag to allow exit

Areas of difficulty

1. Unfamiliarity, n=5
2. Having extra supplies ready e.g. drape tape, opsite, n=2
3. Achieving a good seal, n=2
4. Collapse of bag – suturing difficult, n=1
DISCUSSION

Utilising readily available equipment with standard tracheostomy technique the only difference of the "trach-in-a-vac" is the creation of the isolated NPF. As the airway is entered (normally the moment of danger for release of aerosol) flow occurs and the suction force draws any aerosolised viral particles into the suction system. There should therefore be minimal soiling or aggregation within the NPF as demonstrated in aerosol physics research [4].

The NPF is closed off from the rest of the operating theatre during moments when aerosols are potentially being dispersed. After opening of the airway and tracheostomy tube insertion there will inevitably be some aggregates on the inner surface of the NPF-bag and contents of the NPF which are potentially dispersed by contact when disposing of the contents (to sterilisation) and the NPF-bag and drapes (to contaminated waste containers). We have tried to contend with this potential method of transmission by immediate immersion of the non-disposable NPF contents in hot soapy water and immediate resealing of the NPF-bag after removal of these contents.

One potential criticism of this method is that the NPF-bag itself may become a "bag full of virus", increasing risk to staff when the bag is removed. We have mitigated this risk by applying negative pressure to the bag (so that most or all droplets and aerosols are evacuated), and by careful removal of the bag, avoiding exposing the inner surface to the room.

What does this procedure add to properly applied personal protective equipment (PPE)? It is unproven if the use of the NPF as described in this article decreases the risk to staff over and above properly used PPE. However, correct airborne PPE may not be available in all hospitals, and should include a fit-tested N95 mask as well as goggles or face shield, impervious gown, and gloves. Even when fit-testing of N95 masks is available about 30% of people cannot find an N95 mask which fits their face [5]. Hence, we think the use of the NPF is likely to be safer in most hospitals than PPE alone, and as shown in Figure 5 will decrease concerns of surgeons and other operating theatre staff about their risk of infection.

CONCLUSION

We present a simple technique able to be used with existing operating theatre equipment which minimises possible contamination of the operating theatre by viral aerosolization. In the context of the COVID-19 pandemic we feel this technique should be disseminated immediately to all surgical teams required to perform tracheostomy so practice and equipment checks can be performed prior to possible urgent cases.

REFERENCES