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Novel Approach to Reduce SARS-Cov-2 Transmission during Trans-Oral Robotic Surgery

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Abstract

Background: This study describes a novel approach in the reduction of SARS-CoV-2 transmission during Trans-oral Robotic Surgery (TORS).

Methods: Five patients underwent TORS between 01st February 2020 and 08th May 2020. A sterile plastic drape with water-tight seal was used as an additional physical barrier against droplets and aerosols. Operative diagnosis; droplet count and distribution on plastic sheet and face shields were documented.

Results: TORS tonsillectomy was performed for patients with suspected tonsillar tumour (n=2), and was combined with tongue base mucosectomy for cervical nodal metastatic carcinoma of unknown origin (n=3). Droplet contamination was noted on all plastic sheets (n=5). Droplet contamination was most severe over the central surface at 95.5% (91.7% to 100.0%) followed by the right lateral surface at 4.5% (0.0% to 8.3%). No droplet contamination was noted on the left lateral surface and all face shields.

Conclusion: Plastic drapes can effectively reduce viral transmission to healthcare providers during TORS.

Keywords: Trans-oral robotic surgery; Head and neck cancer; COVID-19; SARS-CoV-2 Transmission; Novel approach

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Introduction

In the current era of minimally invasive surgery, early tumors in the nasopharynx, oropharynx, larynx and hypopharynx can be safely resected *via* the oral cavity using robotic surgical systems, obviating the need for external scars, maxillary swing, mandibulotomy and laryngectomy; reducing side-effects associated with radical radiotherapy +/- chemotherapy; and promoting treatment de-intensification in selected patients [1-4].

The novel Coronavirus Disease 2019 (COVID-19) is caused by SARS-CoV-2 virus. SARS-CoV-2 is found in high abundance in the upper aerodigestive tract mucosa most notably in the nasopharynx and oropharynx [5]. Patients may be asymptomatic at the time of presentation [6]. There is currently no accurate way of diagnosis [7]. Viral transmission is *via* close contact and droplets. Airborne transmission may occur during Aerosol Generating Procedures (AGP) [8]. World Health Organization (WHO), Centers for Disease Control and Prevention (CDC) and Centre for Health Protection in Hong Kong (CHP) recommend full barrier protection when performing AGP for unknown, suspected and confirmed COVID-19 patients in order to avoid disease transmission to health care providers. However, as the number of COVID-19 infected patient's increases worldwide, there is a global shortage of Personal Protective Equipment (PPE) [8-10]. Hence as head and neck surgeons, we are at particular risk of becoming infected when treating patients during the COVID-19 pandemic.

This study describes a novel approach which aims to decrease viral transmission when performing Trans-oral Robotic Surgery (TORS) during the COVID-19 pandemic.

Materials and Methods

All patients who underwent TORS in the Division of Head and Neck Surgery of the Department of Surgery, The University of Hong Kong between 01st February 2020 and 08th May 2020 were included.

Figure 1: Placement of Wishbone® Frame and Omni-Flex® Post after docking for TORS.

All patients underwent work-up for tumour staging. These included clinical and endoscopic examination with biopsy taken for histological confirmation; ultrasonography of the neck +/- fine needle aspiration for cytology of suspected neck nodal metastasis; Magnetic Resonance Imaging (MRI) +/- whole-body Positron Emission Tomography (PET) scans.

As recommended by CHP and hospital infection control unit, admission to head and neck surgical ward was only allowed (1) on declaring absence of travel history 14 days prior to surgery, (2) absence of close contact with confirmed cases, and (3) tympanic body temperature <37.5 degrees Celsius taken at ward entrance. On admission, routine bloods including white cell count and chest X-ray were checked. Two sets of Polymerase Chain Reaction (PCR) test for nucleic acid sequence homology in nasopharyngeal and throat swabs taken 24 h apart would only be tested for febrile and symptomatic patients +/- radiological changes on chest X-ray.

All operations were performed by a consultant surgeon experienced in head and neck robotic surgery, accompanied by 1 surgical assistant who has completed his/her fellowship training in head and neck surgery and is licensed to perform head and neck robotic surgical procedures, 1 scrub nurse who is familiar with the robotic surgical procedures, and 1 consultant anesthetist. Full barrier protection was adopted by all parties, including goggles, N95 respirator, face shield, gowns and gloves.

After nasal-tracheal intubation by anesthetist, skin was prepared and draped with disposable surgical drapes (3M Hong Kong) in the usual manner for TORS, exposing the oral cavity, bilateral neck and sternal notch. A Fr 16 Nelaton catheter was inserted *via* the remaining nostril for suction of saliva, secretions and any aerosols generated intra-operatively. The Nelaton catheter was connected to a surgical suction system connected to smoke and High-efficiency Particulate Air (HEPA) filters. Boyle-Davis retractor was used for exposure of the oropharynx and was fixed to patient's left bedside. Docking of Da Vinci Xi Robotic System (Intuitive Surgical Inc., Sunnyvale, CA, USA) and deployment of endowrists was performed trans-orally consisting of a three-dimensional high-definition camera, Maryland forceps and Spatula. Omni-tract® Fast System® Standard Wishbone® Frame 4020 (Integra Life Sciences Corporation, Ohio, USA) was positioned cranial to patient's vertex and fixed to patient's left bedside using the Omni-Flex® Post (Integra Life Sciences Corporation, Ohio, USA) (Figure 1).

Figure 2: Placement of 2 sterile plastic sheets over the operative field. The cranial sheet was fixed with 4 sterile clamps on the Wishbone® Frame. The 2 sheets were taped together using adhesive 3M tape. Additional adhesive 3M tape was used to create a water-tight seal at three-point junctions between the 2 plastic sheets and each of the 3 robotic cannula.

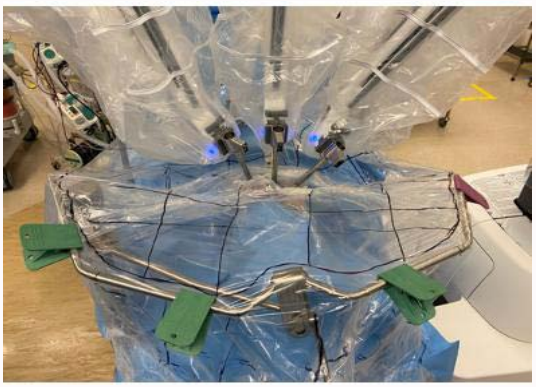

Figure 3: Placement of grids on plastic sheet on completion of TORS.

Two clear and sterile plastic sheets, each measuring 120 cm × 140 cm was draped over the operating field: 1 plastic sheet was secured to the Wishbone frame with 4 sterile clips so that the free edge of the sheet reached the caudal half of all 3 robotic canula; using adhesive 3M tape the second plastic sheet was taped to the free edge of the first plastic sheet. Additional adhesive 3M tape was used to create a water-tight seal at three-point junctions between the 2 plastic sheets and each of the 3 robotic cannulas. The free edge of the second sheet was then draped loosely over the Boyle-Davis suspension bar and taped to surgical drapes over the caudal, left and cranial ends using adhesive 3M tape, leaving the right side untapped for the surgical assistant to work under (Figure 2). A 1 cm fenestration was made over the left upper corner of the central operating field for placement of a surgical suction system connected to smoke and HEPA filters. The fenestration was sealed and tubing secured with Tegaderm (3M Hong Kong). Scrub nurse was position opposite the assistant surgeon's right hand. TORS resection of oropharyngeal pathology was performed in the usual manner by the consultant surgeon at the surgeon's console.

On completion of TORS, the plastic sheet was pulled taut, and the central, vertex and bilateral surfaces of the plastic sheet were marked with 7 cm × 7 cm grids (Figure 3, Table 1). The face shield of the

Table 1: Labeling of grids on plastic drape for TORS.

		V10	V9	V8	V7	V6		
		V5	V4	V3	V2	V1		
R7	R1	C1	C2	C3	C4	C5	L1	L7
R8	R2	C6	C7	C8	C9	C10	L2	L8
R9	R3	C11	C12	C13	C14	C15	L3	L9
R10	R4	C16	C17	C18	C19	C20	L4	L10
R11	R5	C21	C22	C23	C24	C25	L5	L11
R12	R6	C26	C27	C28	C29	C30	L6	L12
		C31	C32	C33	C34	C35		
		C36	C37	C38	C39	C40		

Blue: Area of plastic drape on surgeon's side/patient's right side, labeled R1-12.
Yellow: Area of plastic drape over center of operating field labeled C1-40.
Green: Area of plastic drape opposite to surgeon/patient's left side, labeled L1-12.
Grey: Area of plastic drape over vertex, labeled V1-10.

operating surgeon prior to commencing console surgery; and face shields of both the assistant surgeon and scrub nurse post-operation were retrieved. The face shield used was a piece of optically clear, latex free plastic film measuring 32 cm in length and 22 cm in width with foam forehead cushion and elastic strap (A R Medicom Inc (Asia) Ltd.). It covered a full-face length from forehead to neck, with outer edges of the face shield reaching bilateral ears. It had anti-fog and anti-glare properties with no hearing restrictions. Each face shield was put against a white background with 12 grids measuring 7 cm × 7 cm each to facilitate counting at maximal magnification [11]. Each plastic sheet was carefully removed and placed against a white background for counting. The number and size of droplets splashed in each grid of the plastic sheet and face shield was counted using the surgical microscope Leica M720 0H5 (Leica Microsystems GmbH, Germany) [12]. The plastic sheets and face shields were discarded once counting was complete.

Operative diagnosis and procedure; size, number and distribution of droplets on plastic sheets and face shields for each party were documented.

Results

Five patients with no clinical evidence of COVID-19 underwent TORS. Three patients underwent TORS bilateral tonsillectomy and tongue base mucosectomy for cervical nodal metastatic squamous cell carcinoma of unknown origin; and 2 patients underwent TORS bilateral tonsillectomy for incidental finding of asymmetrical Fluorodeoxyglucose (FDG) uptake on whole-body PET scan. Droplet contamination was noted on all plastic sheets (n=5). Droplet size ranged from 0.2 mm to 3.2 mm. Droplet contamination was most severe over the central surface for all patients with an average of 95.5% (91.7% to 100.0%) followed by the right lateral surface at 4.5% (0.0% to 8.3%) There was no droplet contamination noted over the vertex and left lateral surfaces (Table 2). Droplet contamination was mainly over the central part of the plastic drape overlying the site of operation in the oral cavity. Total droplet count was highest along the centre-most column E at 31.3% (n=20). Droplet count decreased towards the periphery on both sides – 21.9% (n=14), 7.8% (n=5) and 4.7% (n=3) at columns D, C and B respectively towards the right, and 23.4% (n=15) and 10.9% (n=7) at columns G and H respectively towards the left. There was no droplet contamination noted along columns A, I and J (Table 3).

Table 2: Droplet count and distribution for TORS patients.

Patient 1:

		V10	V9	V8	V7	V6		
		V5	V4	V3	V2	V1		
R7	R1	C1	C2	C3	C4	1	L1	L7
R8	R2	C6	1	2	1	C10	L2	L8
R9	R3	C11	C12	1	C14	C15	L3	L9
R10	R4	1	1	1	2	1	L4	L10
R11	1	C21	1	C23	C24	C25	L5	L11
R12	R6	C26	C27	C28	1	C30	L6	L12
		C31	C32	C33	C34	C35		
		C36	C37	C38	C39	C40		

Patient 2:

		V10	V9	V8	V7	V6		
		V5	V4	V3	V2	V1		
R7	R1	C1	C2	C3	1	C5	L1	L7
R8	R2	1	C7	1	C9	1	L2	L8
R9	R3	C11	1	2	1	C15	L3	L9
R10	1	C16	1	1	C19	C20	L4	L10
R11	R5	1	C22	C23	1	C25	L5	L11
R12	R6	C26	C27	C28	C29	C30	L6	L12
		C31	C32	C33	C34	C35		
		C36	C37	C38	C39	C40		

Patient 3:

		V10	V9	V8	V7	V6		
		V5	V4	V3	V2	V1		
R7	R1	C1	C2	1	C4	C5	L1	L7
R8	1	C6	1	1	C9	1	L2	L8
R9	R3	C11	1	2	1	C15	L3	L9
R10	R4	C16	1	C18	1	C20	L4	L10
R11	R5	C21	C22	1	C24	C25	L5	L11
R12	R6	C26	C27	C28	C29	C30	L6	L12
		C31	C32	C33	C34	C35		
		C36	C37	C38	C39	C40		

Patient 4:

		V10	V9	V8	V7	V6		
		V5	V4	V3	V2	V1		
R7	R1	C1	C2	C3	C4	C5	L1	L7
R8	R2	1	1	1	1	1	L2	L8
R9	R3	C11	C12	1	C14	C15	L3	L9
R10	R4	C16	1	C18	1	1	L4	L10
R11	R5	C21	C22	1	C24	C25	L5	L11
R12	R6	C26	1	C28	C29	C30	L6	L12
		C31	C32	C33	C34	C35		
		C36	C37	C38	C39	C40		

Discussion

SARS-CoV-2 is transmitted through close contact and droplets. Airborne transmission may occur during AGP including tracheal

Patient 5:

		V10	V9	V8	V7	V6		
		V5	V4	V3	V2	V1		
R7	R1	C1	C2	C3	C4	C5	L1	L7
R8	R2	C6	1	1	1	C10	L2	L8
R9	R3	1	1	1	2	1	L3	L9
R10	R4	C16	1	1	1	C20	L4	L10
R11	R5	C21	C22	1	C24	C25	L5	L11
R12	R6	C26	C27	C28	C29	C30	L6	L12
		C31	C32	C33	C34	C35		
		C36	C37	C38	C39	C40		

Table 3: Total droplet count and distribution of droplets for TORS patients.

	A	B	C	D	E*	F	G	H	I	
1	0	1	1	3	4	4	2	0	0	15
2	0	1	2	2	4	3	1	0	0	13
3	0	1	0	3	5	2	1	0	0	12
4	0	0	1	3	3	2	2	0	0	11
5	0	0	1	3	4	4	1	0	0	13
	0	3	5	14	20	15	7	0	0	64

Column A: R7-12
Column B: R1-6
Column C: V10,V5,C1,C6,C11,C16,C21,C26,C31,C36
Column D: V9,V4,C2,C7,C12,C17,C22,C27,C32,C37
Column E: V8,V3,C3,C8,C13,C18,C23,C28,C33,C38 (* Centre-most column)
Column F: V7,V2,C4,C9,C14,C19,C24,C29,C34,C39
Column G: V6,V1,C5,C10,C15,C20,C25,C30,C35,C40
Column H: L1-6
Column I: L7-12

intubation, tracheotomy and manual ventilation before intubation, non-invasive ventilation, cardiopulmonary resuscitation and bronchoscopy. WHO, CDC and CHP recommend full barrier protection when performing AGP for unknown, suspected and confirmed COVID-19 patients in order to avoid disease transmission to health care providers, these include gloves, goggles, face shield and gowns, as well as items filtering facepiece respirators such as N95 or powered air-purifying respirator hoods and aprons [8-10]. In order to reduce chance of viral transmission and conserve PPE at times of global PPE shortage, the number of health care providers in the operating theatre was minimized to just 1 consultant surgeon who specializes in the field of head and neck robotic surgery, 1 assistant surgeon who has completed his/her fellowship in head and neck surgical training with a license to perform robotic surgery, and 1 scrub nurse experienced in the head and neck robotic surgical procedures. A team comprising of the most experienced medical staff would help to minimize operating time, blood loss, duration of aerosol exposure, peri-operative morbidity and hospital stay, ultimately reducing the chance of viral transmission to health care providers and other patients.

During the COVID-19 outbreak, there are concerns regarding endoscopic approaches to the skull base, nasopharynx and oropharynx as a result of the high viral load within the nasopharynx and oropharynx, and the risks of aerosolization of blood and irrigation fluids generated by diathermy and high-speed debrides and drills [13,14]. In theory, the risk of aerosolization and viral transmission to health care providers is lower with robotic surgery as a result of the lack of bone instruments such as high-speed debrides and drills; the surgeon operates from a surgeon console which is away from the operative field; the surgical assistant and scrub nurse are both situated further away from the operative field when compared with endoscopic and open approaches. Careful tissue dissection, avoidance of unnecessary irrigation and vigilant suction of secretions, blood and irrigation fluid, and careful removal and placement of robotic surgical instruments through robotic cannula can help to minimize aerosol spillage and viral transmission.

In order to diminish risk of droplet and aerosol contamination, the following steps were taken prior to docking: (1) ensure that the cuff of the endotracheal tube was inflated with no evidence of air leak (2) a Fr 16 Nelaton suction catheter connected to a surgical suction system with smoke and HEPA filters was placed in the remaining nostril for suctioning of saliva prior to docking and also of blood, diathermy smoke and aerosols generated during the operation. The position of the Nelaton tube could be adjusted as required throughout the operation [15].

In this study, we proposed the use sterile supports and a clear plastic sheet draped over the operative field, which acted as an additional physical barrier against droplet and aerosol spillage. To our knowledge, such an approach has not been described in literature. The rationale was to create a water-tight, spacious and sterile closed environment which enabled free movement of robotic arms, and for the assistant surgeon to work in whilst preventing droplet and aerosol spillage, ultimately reducing the chance of viral transmission.

After docking of robotic arms and deployment of endowrists, the Wishbone® Frame was positioned and fixed with the Omni-Flex® Post. This was to ensure that neither the Omni-Flex® Post nor Wishbone® Frame would hinder docking and/or result in inadvertent collisions with the robotic arms. The Wishbone® Frame was positioned well above patient's vertex and extended to ensure maximal angulation at each joint, which in turn increased working space. The height of the Wishbone® Frame could be adjusted by the surgeon to ensure adequate working space of the robotic arms and assistant surgeon whilst not obstructing anesthetist's access to the endo-tracheal tube if need be. The Omni-Flex® Post was fixed on the same side as the Boyle-Davis support, usually to patient's bedside on the left so as to ensure maximal working space for the assistant surgeon on the right side.

Two clear sterile plastic sheets re-inforced at the junction with adhesive 3M tapes were used to create a giant sterile drape over the operating field, whilst accommodating the 3 moving robotic arms. Additional adhesive 3M tape was used to re-inforce three-point junctions between the 2 plastic sheets and each of the 3 robotic cannulas to create a water-tight seal. The plastic sheets were draped loosely over the Wishbone® and Boyle-Davis suspension frames to allow for stretching and movement of the plastic sheet with the 3 robotic arms. Such a set up was deemed superior than using one single plastic sheet with 3 fenestrations to cater for the robotic arms, as the moving robotic arms would enlarge the fenestrations, which in turn would allow droplet and aerosol spillage. Cranial, caudal and left lateral edges of the giant plastic sterile drape was taped to surgical drapes to create a closed sterile environment using adhesive 3M tape, leaving the right lateral edge untapped whereby the assistant surgeon worked under. Furthermore, placement of negative pressure surgical suction system opposite the assistant surgeon enabled safe removal of smoke and aerosols generated during the procedure which further decreased risk of viral transmission, in addition to prevention of fogging and resultant impaired visibility.

Droplet contamination was most severe over the central surface which was directly over the operative field in the oral cavity (95.3%). There was minimal droplet contamination on the right lateral surface (4.5%), whereby the plastic sheet acted as a hood protecting the assistant surgeon against droplet and aerosol contamination. No droplet contamination was noted on the contralateral surface for all patients. Face shields of the operating surgeon on docking; and face shields of the assistant surgeon and scrub nurse throughout the operation were clear of droplet contamination. Although aerosol particles were too small to be visualized under the surgical microscope, the ability to contain droplets under the water-tight sealed plastic drapes suggested that such a set-up was effective in preventing both droplet and aerosol spillage during TORS. Proper disposal of plastic drapes were imperative in the prevention of viral transmission to health care workers.

Results from our preliminary study suggested that the proposed set-up could effectively prevent droplet and aerosol contamination during TORS. Such an approach can also be advocated for other AGP and endoscopic head and neck surgical procedures in an attempt to reduce droplet and aerosol contamination, and ultimately viral transmission to health care providers.

Larger scale studies with more patients and operating surgeons is warranted to justify such recommendations. Ideally commercially made sterile plastic drapes incorporating cannula covers and closed systems with negative pressure would help to further decrease spillage around cannula during movement of robotic arms.

Conclusion

The creation of a water-tight, sterile and closed environment with sterile plastic drapes effectively prevents droplet and aerosol spillage when performing TORS for all unknown, suspected and confirmed COVID-19 patients, which in turn helps to minimize the chance of viral transmission to health care providers. Such a set-up is functional, readily available and cost effective. The aforementioned approach should be considered to support safe clinical practice and efficient use of resources during the COVID-19 pandemic.

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