

# Aerosol-generating procedures, how best did anesthesiologists use available personal protective equipment during early COVID-19 pandemic in a tertiary care center of southern India? A prospective cross-sectional study

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## Abstract

**Background and Aims:** Anesthesiologists are involved in high-risk procedures for transmission of SARS-CoV-2 like aerosol-generating procedures (AGPs). The present study was conducted to assess the compliance toward the use of personal protective equipment (PPE) and proposed modifications in anesthesia techniques to prevent dissemination of the virus among healthcare workers.

**Material and Methods:** This prospective cross-sectional study was conducted during the first wave of the COVID-19 pandemic and included all elective surgeries involving AGPs inside operation theatres and remote areas. Participants were anesthesia consultants and trainees. Trained anesthesia technicians observed and documented all the AGPs and data entry with analysis was done using EPI Data 3.1, SPSS 21.0. Descriptive statistics were reported using mean  $\pm$  SD for continuous variables.

**Results:** Preoperative COVID-19 test was done in 96.3% of patients. Most (74.8%) of the AGPs were performed by consultants. In our study, compliance for N95 masks usage and hand hygiene was found to be 99.2% and 55.9%, respectively. Avoidance of crowding was followed in only 38.9% during intubation. To contain the aerosol-based spread of virus, modification of anesthesia practices like acrylic boxes (6.4%), plastic sheets (5.5%), video laryngoscopy (39%), rapid sequence intubation (RSI) (42.7%), and 59.3% of deep extubation were incorporated.

**Conclusion:** In our study, we found satisfactory compliance toward usage of N95 masks alone, whereas compliance toward other available PPE and modification in anesthesia practice was found to be unsatisfactory.

**Keywords:** Anesthesiologists, aerosol-generating procedures, personal protective equipment, SARS-CoV-2 pandemic

## Introduction

The transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) during the early part of pandemic was predominantly thought to be due to droplet infection, fomite, and airborne. Due to resemblance of SARS-CoV-2 with SARS-CoV, MERS and Influenza virus, airborne

mode of transmission was emphasized. Anesthesiologists are involved with aerosol-generating procedures (AGPs) resulting in high risk of infection to healthcare workers (HCWs) on a daily basis.<sup>[1,2]</sup> Various policies across the globe were proposed like minimizing crowding in operation theatres (OTs), hand hygiene (HH) to reduce the contact transmission, use of N95

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masks for HCWs in close contact with AGPs, and modification of anesthesia practices to minimize or to contain the viral spread. Strong evidence to support the route of transmission was lacking but in view of the fatalities and disabilities due to the SARS-CoV-2 virus, all possible precautions were implemented. Despite the availability of personal protective equipments (PPEs), there was anxiety<sup>[3]</sup> and reluctance in complying toward the optimal PPEs usage,<sup>[3]</sup> anesthesia technique modifications, probably due to emerging disease unfolding different aspects and understanding toward the disease, discomfort while using the PPEs, lack of discipline, and inability to adjust to new protocols were a few reasons for the reduced compliance among frontline workers. Primary aim of the study was to evaluate the compliance toward the usage of PPEs and secondary aim was to evaluate the compliance toward the modification of anesthesia techniques to minimize the spread of virus.

## Material and Methods

We observed AGPs in OTs and remote areas of anesthesia like magnetic resonance imaging (MRI) suites, gastroscopy rooms, catheterization laboratories for HH, appropriate use of PPEs, and modification in anesthesia practice during the first wave of COVID-19 pandemic after institutional research board (IRB) approval (IRB No. 12872/dated 15-06-2020). Our study was done in the Department of Anesthesiology, in a tertiary care center, in southern India, for a period of 10 days. No similar study was done as this is an unprecedented situation, so our sample size included all AGPs done (218) during the study period. We also evaluated rate of preoperative testing of patients, usage of masks among patients perioperatively, and limiting the total number of personnel while performing AGPs. The participants in the study were consultants and trainee anesthesiologists. Trained anesthesia technicians observed all the AGPs as per proforma.

With the onset of pandemic, anesthesiologists were updated via online talks, e-modules, and video demonstrations regarding institutional recommendations on HH, utilization, and proper disposal of PPE, as well as the department policy on anesthesia modifications to prevent the viral spread. Our institutional recommendations were based on Centres for Disease Control and Prevention (CDC) recommendations<sup>[4,5]</sup> which were modified to suit our needs. A departmental core team was constituted to draft the protocol for PPE usage and modification of anesthesia technique for ensuring the safety of HCWs in OT and at the same time making sure the judicious use of PPE for our set up. The technicians were then trained by the investigating team to directly observe the parameters in a standard way. Pilot study on 10 patients helped in the

development of the final proforma to document the findings, and the findings of the pilot study were not included in the final data analysis. AGPs encountered by the anesthesiologists are preoxygenation, intubation, nasogastric tube placement, extubation, tracheostomy, gastroscopy, endotracheal suctioning, and colonoscopy. For the purpose of our study, we observed preoxygenation, intubation, and extubation as representative of AGPs. In our institution, adequate PPEs, alcohol-based hand rub, and soap were available to all the HCWs throughout the pandemic period. The available PPEs included a surgical hood, head cap, surgical mask, N95 mask, goggles, face shields, visors, impermeable surgical gown, foot cover, and gloves. To minimize the spread of the virus, acrylic boxes, video laryngoscopes, and transparent plastic sheets were used to cover the patient's upper part of the body during AGPs. Modified anesthesia techniques such as rapid sequence intubation (RSI), avoidance of bag and mask ventilation (BMV), and deep extubation were also preferred over the routine practices.

The AGPs of elective procedures conducted during regular working hours were included. Patients with the American Society of Anaesthesiologists (ASA) physical status IV, difficult airway, untested for SARS-CoV-2, and emergency cases were excluded from the study. We defined recommended and desired HH times for standardization of the observation. Both hand washes with antimicrobial soap and alcohol-based hand rub along with change of gloves were considered as an optimal hygienic approach. Hand wash for 20 s at least three times at first contact with the patient, after AGPs, and after extubation was considered recommended, whereas seven times per procedure (before patient receiving, after shifting to OT table, before AGPs, after AGPs, during surgery, before extubation and before shifting to recovery) was considered desirable. For the purpose of the study, recommended HH is acceptable.

Data entry were done using EPI Data 3.1. Data analysis were done using a statistical package for the social sciences (SPSS) 21.0. Descriptive statistics were reported using mean  $\pm$  SD (standard deviation) for continuous variables. Categorical variables were reported using frequency and percentage.

## Results

A total of 218 elective anesthetic procedures were observed of which 95.4% were conducted in OTs. In addition, 75% of the observed anesthesiologists were consultants and 25% were trainees. Furthermore, 60.6% of our patients, ranging from 1 month to 81 years, were male and 93% belonged to

ASA I and II category. A total of 80.3% of our procedures were performed on adults and 19.7% were on children.

The following six strategies were adopted to minimize the infection among healthcare workers:

1. Testing of patients
2. Patients shifted with face mask into OT and out of OT
3. HH compliance
4. Limiting personnel during AGP
5. Use of PPE and appropriate disposal
6. Modification of anesthesia practices.

A total of 96.3% of patients were tested with real-time reverse transcription-polymerase chain reaction (RT-PCR) for COVID-19. The testing policy during the early phase of COVID-19 pandemic was not very clear and was based on the symptoms of acute respiratory illness of the patient and the surgeon's request.

Ward staffs were instructed to shift all patients with surgical masks to OT irrespective of the test result to minimize the spread of the virus. In our study, we found 87.6% [Table 1] compliance toward this policy, whereas 0.5% of total patients were intubated while shifting. Only 50% of the patients were shifted out of OT to post anesthesia care unit (PACU) with surgical face masks and 3.2% of our patients were shifted to ICU intubated. All intubated patients were shifted out on the bair circuit with a heat and moisture exchange (HME) filter at the patient end.

Availability of soaps and alcohol-based solutions for HH was 100% in OT and remote locations. In our study, 55.9% [Table 1] of anesthesiologists maintained minimum criteria of HH and only 0.9% followed the desirable number of handwashing which was approximately seven times per patient during surgery. Compliance for HH after intubation was 41.8%, whereas after extubation was 37.7% only.

Acceptable HCW allowed at the time of AGPs in OTs were anesthesiologist, technician, and a floor nurse. We noticed compliance for a limited number of HCW was as low as 38.9% at intubation and 41.2% at extubation [Table 1] for adult patients. The compliance for limiting the number of HCW was only 13% for pediatric patients and crowding (>8 HCWs) was noticed in complicated cases like pediatric open airway.

Compliance toward N95 mask and visor was as high as 99.2% and 84.4% at intubation and 96.8% and 85.8% [Table 2] at extubation, respectively. Compliance toward surgical gown use was observed to be 64.7% for intubation and 72.9% for extubation. Anesthesia technicians' compliance toward

the N95 mask, surgical gown, and visor was observed to be 95.9%, 83.5%, and 82.6%, respectively.

We noticed that 47.2% of anesthesiologists disposed of the PPE inside OT and the rest of the disposals happened after shifting the patient to post anesthesia care unit (PACU). There was a change of anesthesia plan in 14.7% due to airway difficulty and 71.9% of the anesthesiologists maintained the PPE standards.

Our institute being a teaching hospital, AGPs are performed generally by trainees under supervision but during the COVID-19 pandemic, 74.8% of the procedures were performed by consultants. To contain the aerosol-based spread of the virus, many techniques were used like acrylic boxes and plastic sheets. Acrylic boxes were made locally and were used in 6.4% of intubations and 3.2% of extubations. Moreover, 5.5% of intubations were done under plastic sheet cover with video laryngoscope and 14.2% of extubations were done, with an oxygen source, under cover of plastic sheet.

Most of the patients were preoxygenated with tidal volume breaths. A total of 88.5% of total inductions were intravenous, whereas 11.5% were inhalational, which mainly were pediatric cases. In addition, 50.5% of the BMV were performed with one hand technique, whereas 7.8% of anesthesiologists used two hands technique. The technique of holding a mask, when ventilated, continued to be mainly EC in 54.1%, whereas 5.5% modified their mask-holding technique to VC as suggested by many studies during COVID-19 pandemic. Furthermore, 42.7% of intubations were RSI<sup>[6]</sup> and 59.6% anesthesiologists continued to use Macintosh laryngoscope for intubation, whereas 39.4% used videolaryngoscopes [Table 3]. After intubation, the cuff was inflated before connecting to the closed circuit in 72.5% of the cases. At the end of the surgery, 59.2% of patients were extubated deep to avoid coughing to minimize the aerosol generation.

## Discussion

The maximum SARS-CoV-2 viral load is found in sputum and upper airway secretions, thus predominantly spread via droplet and contact route. The larger respiratory particles (>5 µm) are contained in a meter radius due to gravitational force and thus bring in the importance of social distancing of 2 m and PPEs usage.<sup>[3]</sup> Virus can be alive on surfaces for days and hence spreads infection once in contact with these surfaces so it becomes essential to follow recommended HH policies and PPEs appropriate usage. Smaller particles <5 µm circulates in air for prolonged periods and get absorbed by respiratory mucosa

**Table 1: Protective steps taken to minimize the spread of virus**

PROTECTIVES STEPS FOR PREVENTING COVID-19 INFECTION			
Strategies	Yes	No	
1. COVID-19 testing	96.3%	3.7%	
2. Patient shifted with face mask			
From ward to OT	87.6%	11.9% (0.5% shifted from ICU intubated)	
From OT to PACU	50%	46.8% (3.2% shifted to ICU intubated)	
3. Hand hygiene	Overall	During intubation	During extubation
Desirable	(>7 times) 4.1%	two times (before and after)	two times (before and after)
Recommended	(4-6) 56.0%	(2 times) 1.4%	(2 times) 0.5%
Noncompliant	(<3) 39.9%	(1) 40.4%	(1) 37.2%
4. Limiting healthcare personnel inside theatre	minimum recommended (<4)	Regular (4 to 7)	Overcrowded (>7)
	Intubation/extubation	Intubation/extubation	Intubation/extubation
	38.9%/41.2%	33.0%/28.6%	27.9%/30%

During intubation: minimum HCWs noted was 2 (1.4%) and maximum was 17 (0.5%) for pediatric open-airway case

**Table 2: Usage of available personal protective equipment (PPE)**

PPE	During Intubation	During Extubation	By Technicians
N95	99.2%	96.8%	95.9%
Surgical gown	64.7%	72.9%	83.5%
Visor	84.4%	85.8%	82.6%
Head cover	3.7%	3.7%	0.9%
Eye cover/Goggles	87.2%	12.8%	82.6%
PPE disposal	Inside theatre	47.2% In PACU	52.8%
Change of airway plan	No:	85.3% Yes:	14.7%
PPE protection	dropped in 26.6% due to change in plan		

**Table 3: Modifications in anesthesia technique**

MODIFICATION IN ANESTHETIA TECHNIQUE			
AGPs performed by	Consultant 74.8%	Trainee	25.2%
Use of acrylic box	Intubation 6.4%	Extubation	3.2%
Use of plastic sheet	Intubation 5.5%	Extubation	14.2%
Preoxygenation technique	Normal breaths 74.8%	Deep breaths	25.2%
Induction	Intravenous 88.5%	Inhalational	11.5% (pediatric cases)
Bag and mask ventilation	One hand 50.5%	Two hands 7.8%	Not done 41.7%
Airway manoeuvre	EC 54.1%	VC 5.5%	40.4%
Intubation	RSI 42.7%	No RSI 56.9%	0.4% shifted with ETT
Laryngoscope	C-MAC 39%	Macintosh 59.6%	Open airway 1.4%
Cuff inflated	Before connecting to circuit 72.5%	After circuit connection 22%	Not done 5.5% (Uncuffed tube/open airway)
Extubation	Deep 59.3%	Awake	40.7%

and conjunctivae of the personals breathing the same air. It is important to maintain air exchanges and to wear N95 in closed places like theatres and ICUs where AGPs are performed.

With standard PPE usage (N95 mask, eye protection, gown, and gloves), the risk of transmission was found to be minimal and thus the anxiety about optimal PPE availability during AGPs in the COVID-19 pandemic was found to be as high as 70% and availability of PPE did not guarantee the adequate compliance to new policies which ensured the safety of HCWs.

Our study was conducted at the time of the first COVID-19 wave, in a tertiary center of southern India, when a logical approach toward minimizing spread in high-risk procedure was tried, and due to the absence of evidence, no clear-cut guidelines were available about the usage of PPE and modifications in anesthesia practices.

Preoperative testing was one of the methods adopted to prevent infection by segregating patients with or without infection and allowing the HCWs to be more mindful of wearing the PPE. As per the retrospective cohort study by Williams *et al.*,<sup>[7]</sup> the sensitivity of a single RT-PCR study was 82.2%. During our study, 96.3% of semielective patients were tested with RT-PCR for COVID-19. During the second wave, all elective patients were tested for RT-PCR and the validity of the test was for 5 days.

As an institutional policy, all ward patients were recommended to be shifted with a surgical face mask to OTs or remote locations, but we observed only 87.6% compliance among the ward staff. To improve the compliance regarding patients wearing face masks, checking the presence of surgical mask on patients, was added to WHO checklist. Only 50% of the immediate postoperative patients were shifted out of OT to post anesthesia care unit (PACU) with surgical face masks and 3.2% of our patients were shifted intubated to ICU. The probable reasons have been 59.2% of extubations were deep requiring oral airways to prevent obstruction and to be able to give suction immediately in case the situation arises.

HH is the most important method to prevent healthcare-associated infections (HAI). For the purpose of this study, the HH meant either a hand wash or change of gloves after the unclean procedure or touching unclean surfaces. In our study, 55.9% of anesthesiologists maintained minimum criteria of HH compliance, which meant hand cleaning before receiving the patients, after AGP, and after extubation. Only 0.9% followed the institutional desirable number of standard HH practices, which was approximately seven times per patient during surgery. Compliance for HH during intubation was 41.8%, whereas 37.7% after extubation, which was similar to study of Sagar *et al.* 2020.<sup>[8]</sup> Less compliance to HH could be due to managing COVID-19 negative cases, time constraints, stress, and unwillingness to apply knowledge into practice.

During non-COVID-19 times, we noticed the presence of four to seven HCWs at the time of AGPs routinely. To reduce the chance of spread of infection, the department recommended a minimum number of HCWs in OTs as protocol. Acceptable number of HCW allowed at the time of AGPs were three that included anesthesiologist, technician, and a floor nurse. We noticed compliance for a limited number of HCW was as low as 38.9% at intubation and 41.2% at extubation for adult patients, whereas similar percentage continued to have a regular number of HCW inside the OT. In pediatric patients, probably needed more personnel compliance was only 13%.

PPE can reduce the risk of the spread of infection by covering the exposed body parts. As a part of prevention strategies for AGP performers, the PPE recommended<sup>[3]</sup> and provided by the department were N95, visor, goggles, surgical gown, clean gloves, and head hood. N95 respirators, named for their ability to filter 95% or more of tiny 0.3  $\mu\text{m}$  particles, are the mainstay of protection against airborne pathogens. CDC recommends<sup>[4]</sup> the use of N95 by all HCWs involved in patient care during coronavirus disease 2019 (COVID-19) out of concern for airborne transmission, particularly during exposure to procedures that produce high concentrations of aerosols (like intubation, extubation, and noninvasive ventilation.)

Our compliance toward N95 mask was quite high, similar to Sagar *et al.*,<sup>[8]</sup> whereas unlike observation of low compliance toward the goggles in Archana Lakshmi *et al.*<sup>[9]</sup> study, we had high compliance toward the visor/goggles. As per a recent meta-analysis, gown may protect better against contamination than aprons. Compliance rate for surgical gown was observed to be 64.7% and 72.9% at intubation and extubation, respectively. It could be due to nonbreathable nature of the materials. The above-mentioned PPEs among anesthesia technicians also shows almost similar results which indicate

equal safety measures for all HCWs involved with high-risk procedures.

PPE disposal is equally important to prevent the spread of virus. Even though it was advised to dispose of the used PPE inside the OT; we noticed 47.2% compliance to this practice, and the rest of the disposals were done, after shifting the patient, in PACU. Several logical modifications were tried to contain the virus during the pandemic. Data from SARS epidemic 2002–2003 demonstrate that HCWs involved in intubations had six times more chances of acquiring virus. Keeping this risk in mind, almost 75% of AGPs were performed by consultants during the first wave of pandemics to minimize the aerosolization timings. To contain the aerosol-based spread of virus, many techniques were used like acrylic boxes and plastic sheets. Locally made acrylic boxes<sup>[10]</sup> were tried in only a limited number of cases in our study mainly due to inconvenience while intubating, increased time of intubation hence aerosolization, and decreased success rate in the first attempt. Furthermore, 5.5% of intubations were done under plastic sheet cover<sup>[11]</sup> with video laryngoscope and 14.2% of extubations were done, with an oxygen source under cover of plastic sheet. All these barriers were added to contain the virus spread but immediately was realized that improper use can lead to fomite-borne spread. Apart from one more layer of protection the advantage of sheet was its low cost, easy availability, and disposability. It is to be discarded soon after intubation. Au Yong *et al.*<sup>[11]</sup> used plastic tent or screen for intubation in pandemic time. The sheet technique is intended to protect the operator, but it fails to prevent patient and work surface contamination including the patient's chest and overlying gown or surgical drapes.

Though video laryngoscopes were recommended for intubation during a pandemic,<sup>[12]</sup> in our study it was noticed that anesthesiologists were comfortable and faster with a conventional laryngoscope.

Limitations of our study were the presence of an observer probably could have made the participants more conscious than when not observed directly. Exposure to an additional person during AGPs but the observer had complete PPE and also study group was not high risk for infection.

In our study, we found satisfactory compliance toward usage of N95 masks alone, whereas compliance toward other available PPE and modification in anesthesia practice was found to be unsatisfactory. After our study, we insisted our team to get through with the protocols and emphasize steps to prevent further spread of COVID infection.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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