Risk of bacterial exposure to the anesthesiologist's face during intubation and extubation

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ABSTRACT

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Anesthesiologists are exposed to the risk of infection from various secretions or droplets from the respiratory tract of patients. We aimed to determine bacterial exposure to anesthesiologists' faces during endotracheal intubation and extubation.

Six resident anesthesiologists performed 66 intubation and 66 extubation procedures in patients undergoing elective otorhinolaryngology surgeries. Sampling was performed by swabbing the face shields twice in an overlapping slalom pattern, before and after each procedure. Samples for pre-intubation and pre-extubation were collected immediately after wearing the face shield at the time of anesthesia induction and at the end of the surgery, respectively. Post-intubation samples were collected after the injection of anesthetic drugs, positive pressure mask ventilation, endotracheal intubation, and confirmation of intubation success. Post-extubation samples were collected after endotracheal tube suction, oral suction, extubation, and confirmation of spontaneous breathing and stable vital signs. All swabs were cultured for 48 h, and bacterial growth was confirmed by colony forming unit (CFU) count.

There was no bacterial growth in either pre- or post-intubation bacterial cultures. In contrast, while there was no bacterial growth in pre-extubation samples, 15.2% of post-

extubation samples were CFU+ (0/66 [0%] vs. 10/66 [15.2%], p=0.001), and all the CFU+ samples belonged to 47 patients with post-extubation coughing.

The current study shows the actual chance of bacterial exposure to an anesthesiologist's face during the patient awakening process after general anesthesia. Given that bacterial exposure was detected only in cases of patient coughing, we recommend using appropriate facial protection equipment and careful prevention of patient coughing during this procedure.

Key words : bacterial exposure, cough, extubation, face shield, intubaton

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I. INTRODUCTION

Healthcare workers are exposed to many risk factors for their physical and mental health[1]. Medical procedures for patients with infectious diseases can be dangerous to healthcare workers because of the possibility of infection transmission. Healthcare workers' face, in particular, is highly likely to be contaminated by patients' droplets[2], which can be inhaled into the healthcare workers' lungs or penetrate the wounded skin or mucous membranes of their eyes, nose, and mouth to cause an infectious disease.

The face shield is a representative personal protective equipment (PPE) that protects the facial area. According to the Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO), face shields are required when performing procedures that generate splashes or sprays of blood, body fluids, or respiratory secretions[3]. Facial shields are thought to be an alternative to goggles and masks. In a previous study using a cough aerosol simulator and breathing simulator, the amount of virus on the respirator under the face shield was reduced by 96% when compared to that without the face shield[4]. However, there is relatively scarce data regarding face shields, and further research is needed to better understand and establish their appropriate use[2]. It has been reported that anesthesiologists

can perform endotracheal intubation well while wearing face shields or other PPEs[5]. Nevertheless, many anesthesiologists do not have sufficient knowledge about protective equipment and do not follow the recommended preventive measures (e.g., washing hands and using personal protective equipment)[6,7]

Bacterial exposure to the endoscopist's face shields has been reported[8]. In previous studies that quantified aerosol generation during general anesthesia, aerosols were detected during endotracheal extubation; however, the results were conflicting during endotracheal intubation[9-12]. There have been no studies on bacterial exposure to anesthesiologists' faces during endotracheal intubation, extubation, and airway suction. Therefore, this prospective study aimed to determine bacterial exposure to anesthesiologists' face shields during endotracheal intubation and extubation by comparing pre- and post-procedural samples from face shields.

II. MATERIALS AND METHODS

1. Study participants

This prospective study was conducted in resident anesthesiologists performing endotracheal intubation and extubation in 66 elective otorhinolaryngological surgeries that were expected to be longer than 3 hours. Written informed consent was obtained from all the anesthesiologists enrolled in this study.

2. Sampling methods

To determine bacterial exposure during intubation and extubation, anesthesiologists' face shield bacterial swab sampling was performed in 66 intubation and 66 extubation procedures by the investigator (S. H. Kim). Endotracheal intubation and extubation were

performed by resident anesthesiologists aged ≥ 20 years, wearing a disposable, non-sterile face shield (Figure 1). Before endotracheal intubation and extubation procedures, when the anesthesiologist wore the face shield, the investigator (S. H. Kim) removed the protective film (outer vinyl) of the face shield. The samples were collected from the face shield before and after each procedure. Sampling was performed by sweeping a sterile cotton swab twice over the face shield, including the corners and edges in an overlapping slalom pattern, and at the second time perpendicular to the first direction (Figure 2)[13]. Bacterial swab samples were collected five times from each patient, and a total of 330 samples were collected.

Figure 1. Face shield.

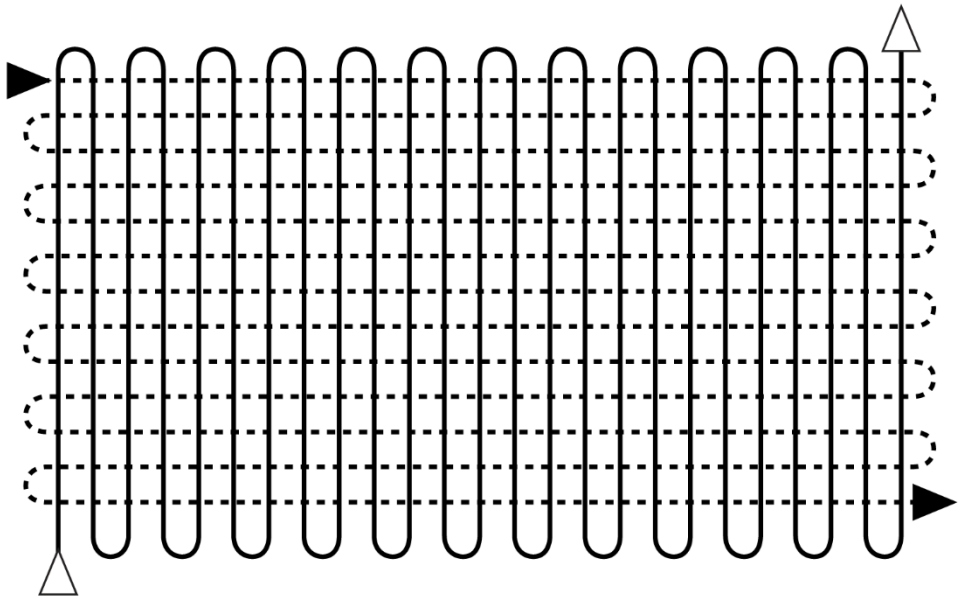

Figure 2. Sampling method.

3. Sampling process

The sampling process was performed for each patient as follows.

A. Pre-intubation sampling: The anesthesiologists wore a disposable, non-sterile face shield before the induction of general anesthesia. The protective film was peeled off immediately after wearing, and a sterile cotton swab was used to collect a sample from the surface of the face shield.

B. Post-intubation sampling: As part of our routine general anesthesia procedure, a nurse administered intravenous anesthetic agents after appropriate monitoring. When the patient's loss of consciousness was confirmed, anesthesiologists performed positive pressure mask ventilation. Endotracheal intubation was

performed after the patient was sufficiently relaxed. Anesthesiologists confirmed the success of intubation through chest auscultation. During this procedure, the anesthesiologists were not allowed to touch the face shield and the investigator monitored for any inadvertent touch. If a touch or other contact occurred, the patient was excluded from the study. After the intubation procedure, the investigator used a sterile cotton swab to collect the sample from the face shield surface in the same manner as pre-intubation sampling.

C. Pre-extubation sampling: When the operation was completed, the anesthesiologists wore a new face shield before the emergence of the patients. Immediately after removing the protective film from the face shield, the investigator sampled the surface with a sterile cotton swab.

D. Post-extubation sampling: The anesthesiologists performed endotracheal tube and oral suction, after which the anesthetic agents were discontinued. Endotracheal 'awake' extubation was performed when the patient responded to the command to open their eyes, and spontaneous breathing was confirmed. After extubation, anesthesiologists checked the patient's consciousness, spontaneous breathing, and vital signs until stable. Throughout the process, any unintentional touching was monitored carefully, and sampling was performed in the same manner as mentioned above. Coughing during the extubation process, if any, was also recorded.

E. Positive control sampling: After extubation, post-extubation positive control samples were collected using a sterile swab from the endotracheal tube tips.

4. Sample culture

The swabs were placed in a transport medium (AM608-2S, Asan pharm Co.,Seoul, Korea) and delivered to Samkwang Medical Laboratories (Seoul, Korea) in a refrigerated state on the day of the procedure. After mixing the solid medium with a cotton swab, the inspectors streaked the medium onto the blood agar and MacConkey agar plate and incubated it at 37°C for 48 h. The results of bacterial growth were reported as the number of colony-forming units (CFU) in all samples. Any growth of CFU ≥ 1 was classified as a positive colony forming unit (CFU+).

5. Primary & secondary outcome

The primary outcome of this study was whether bacterial exposure (reported as CFU+) occurred during endotracheal extubation; therefore, the rate of CFU+ was compared before and after extubation. The secondary outcome was bacterial exposure during endotracheal intubation, which was presented as the rate of CFU+ before and after intubation. Bacterial exposure was also evaluated in a subgroup of patients who coughed during endotracheal intubation and extubation.

6. Sample size

Considering that there was a 17% or greater chance of exposure to droplets or blood to medical personnel during various surgeries and procedures[8,14,15], this study assumed a 17% increase in the CFU+ ratio to be a significant difference (power 0.80, type 1 error rate 5%). The sample size to confirm the 20% difference was 60 patients; therefore, 66 patients were sampled before and after the procedures, considering 10% dropouts.

7. Statistical analysis

CFU+ and positive exposure rates before and after the procedure were analyzed using the chi-square test. Statistical analyses were performed using SPSS Statistics 26 (SPSS Inc. USA). Statistical significance was set at $P < 0.05$.

III. RESULTS

In the study, there were no excluded cases of unintentional touch to the face shield.

1. Pre- and post-extubation samples

Although there was no bacterial growth in the pre-extubation samples, 15.2% of the post-extubation samples were CFU+ (0/66 [0%] vs. 10/66 [15.2%], p=0.001). CFU+ in the post-extubation positive control sampling was 98.5%. A total of 47 patients coughed after extubation, and bacterial growth was observed only in these patients. In this subgroup where patient coughed, CFU+ was different after extubation compared to before extubation (0/47 [0%] vs. 10/47 [21.3%], p=0.001). The number of CFU in pre- and post- extubation samples is presented in the Table 1.

2. Pre- and post-intubation samples

In contrast, 14 patients had a cough during anesthetic induction after opioid administration; however, there was no bacterial growth in pre- and post-intubation bacterial cultures.

Table 1. Number of bacterial colony-forming unit (CFU) count in pre- and post-extubation samples taken from the anesthesiologist's face shield

	No growth	1–15 CFUs	16–30 CFUs	> 31 CFUs
Pre-extubation	66 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Post-extubation	56 (84.8%)	6 (9.1%)	3 (4.5%)	1 (1.5%)

IV. DISCUSSION

This study demonstrates the bacterial exposure to the face of anesthesiologists during the patient awakening process after general anesthesia, including endotracheal extubation and oral suction procedures. This result is meaningful in that it directly investigated bacterial exposure on the anesthesiologist's face and showed that the extubation procedure can transmit pathogens. In particular, bacterial exposure was detected only in cases of patient coughing, implying the importance of preventing coughing during the procedure. In contrast, during the general anesthetic induction process, including positive-pressure mask ventilation and endotracheal intubation, we could not confirm bacterial exposure to the anesthesiologist's face.

In our study design, 'awake' endotracheal extubation was performed when the patients were fully alert and able to respond appropriately to anesthesiologists' commands, which increased the potential risk of post-extubation coughing. Coughing produced the greatest number of aerosol particles among six respiratory activities, including quiet breathing, talking, exercise, shouting, and forced expirations, particularly increasing the particle count 370.8-fold compared with quiet breathing[16]. Recent studies that quantified the amount of aerosol generation during general anesthesia have shown that patient coughing during

extubation increased the amount of aerosol generation[10-12], which is consistent with our study result that all positive bacterial exposure belonged to extubation cases with patients coughing. According to previous studies[9,11,12], endotracheal extubation produces aerosols, but the amount was comparable to or less than that of coughing. Therefore, based on our study, post-extubation coughing could be considered an important factor in bacterial exposure during this procedure.

Regarding endotracheal intubation, our study did not find any evidence of bacterial exposure to the anesthesiologist's face during the procedure. The results of previous studies on whether this procedure is aerosol-generating are inconsistent. While Dhillon et al. found that the aerosol concentration was 12 times greater than the baseline during the entire anesthesia induction procedure (passive oxygenation, bag mask ventilation, tube insertion)[10], intubation generated only slightly more aerosol than the baseline in another study[9]. In our study, bacterial growth was not observed during the anesthetic induction process, even in cases with coughing. During the induction, we used a facial mask for preoxygenation and positive pressure ventilation, and the mask placed between the anesthesiologist's face and the patient's mouth could be one of the possible reasons for preventing bacterial exposure during this procedure. Considering that coughing can produce aerosols even under continuous positive airway pressure and high-flow nasal oxygenation ventilation[17], tight mask sealing and minimizing air leaks are still important during anesthetic induction.

Medical personnel are usually unaware of patients' body fluid exposure during the procedures, but various medical procedures have the potential to expose health care workers to body fluids and pathogens. Blood spatter and body fluid splashes on protective glasses and masks during various surgeries have been reported previously[14,15].

Anesthesiologists also can be easily exposed to blood or secretion from the patient's upper respiratory tract and stomach, which can be a carrier of pathogens[18,19]. The incidence of post-extubation cough was reported to be 10–100%[20,21], and cough during extubation might cause potential complications such as increased intracranial pressure, increased intraocular pressure, and neck hematoma in otorhinolaryngological surgeries. During the COVID-19 pandemic era, as airway maneuvers are recognized as a source of infection, careful airway management techniques to reduce the transmission of infection sources have become more important[22]. Therefore, along with appropriate PPE, strategies to reduce the incidence of coughing by choosing non-irritant anesthetic agents, 'deep' extubation technique[23], and maintenance of low dose opioid[24,25] during extubation might be beneficial.

This study had some limitations. First, only bacterial exposure was examined, and exposure to viruses or other microorganisms was not investigated. Further studies of other pathogens should be conducted to determine the risk of infection. Second, we did not identify the exact bacterial species. Third, the relationship between facial exposure and the actual incidence of infectious diseases is unclear. Whether facial exposure leads to the transmission of disease can vary, as additional processes such as droplet inhalation or mucosal penetration of pathogens must precede.

V. CONCLUSION

In conclusion, this study demonstrated the possibility of bacterial exposure during oral suctioning and endotracheal extubation. This exposure can pose a potential risk of infection for anesthesiologists. In addition, coughing during extubation appears to play an important role in bacterial exposure during the procedure. Based on the results of our study, we recommend that extubation should be performed carefully to reduce patient coughing, and

appropriate facial protection equipment should be used during this procedure.

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ABSTRACT(IN KOREAN)

기관 삽관 및 발관 시술 중 시술자의 안면에 대한 박테리아 노출 위험

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송 세 한

마취과 의사는 환자의 호흡기에서 나오는 다양한 분비물이나 비말로 인한 감염 위험에 노출되어 있다. 이 연구는 기관 내 삽관 및 발관 동안 마취과 의사의 얼굴에 대한 세균 노출을 확인하는 것을 목표로 했다.

6명의 마취과 레지던트가 이비인후과 정규 수술에서 66회의 삽관 및 66회의 발관 시술을 수행하였다. 검체는 각 시술 전후에 안면보호구 표면을 멸균 면봉을 이용해 슬라롬 패턴으로 2회 겹쳐 긁어 채취하였다. 삽관 및 발관 전의 검체는 각각 마취 유도 시와 수술 종료 시, 안면보호구를 착용한 직후에 채취하였다. 삽관 후 검체는 마취제 주입, 마스크 양압 환기, 기관 내 삽관 및 청진을 통한 삽관 성공 확인 후 채취되었다. 발관 후 검체는 기관내관 흡인, 구강 흡인, 기관내관 발관 및, 발관 후 자발 호흡과 활력 징후의 안정을 확인 후 채취되었다. 모든 스왑 검체는 48시간 동안 배양되었고, 세균 성장은 집락형성단위(CFU) 계수를 통해 확인하였다.

삽관 전후 검체의 세균 배양에서는 세균 성장이 확인되지 않았다. 대조적으로, 기관 발관 전 검체에서는 세균 성장을 확인할 수 없었으나, 발관

후 검체의 15.2%는 배양 양성 (0/66 [0%] vs. 10/66 [15.2%], p=0.001) 소견을 나타냈다. 발관 후 기침을 한 환자는 총 47명이었고, 이 환자들에서만 세균이 배양되었다.

이 연구는 전신 마취 후 환자가 깨어나는 과정에서 마취과 의사의 얼굴에 세균이 노출될 가능성을 보여주었다. 환자가 기침을 하는 경우에서만 세균 노출이 확인된 것을 감안할 때, 시술 중 적절한 안면 보호 장비 착용 및 기관내관 발관 중 기침 예방이 중요하다고 사료된다.

핵심되는 말 : 기관 내 삽관, 기관내관 발관, 기침, 세균 노출, 안면보호구