

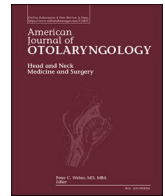


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American Journal of Otolaryngology–Head and Neck Medicine and Surgery

journal homepage: www.elsevier.com/locate/amjoto

A more secure and effective method for throat swab collection: The importance of adequate exposure of oral cavity in COVID-19 specimen collection

Minghao Zhang^a, Yujie Yang^b, Peng Qu^c, Yuchen Fan^d, Zhihao Niu^d, Xu Bao^d, Li Tian^e, Fangmin Chen^{a,*}

^a Department of Urology, Tianjin Third Central Hospital, Tianjin 300170, China

^b Department of Pediatrics, Tianjin Third Central Hospital, Tianjin 300170, China

^c Admin Office, Tianjin Third Central Hospital, Tianjin 300170, China

^d Department of General Surgery, Tianjin Third Central Hospital, Tianjin 300170, China

^e Director of Nursing, Tianjin Third Central Hospital, Tianjin 300170, China

ARTICLE INFO

Keywords:

COVID-19
Throat swab collection
Safety
Oral exposure

ABSTRACT

Objectives: This study aims to propose a novel and effective throat swab collection method for coronavirus disease 2019 (COVID-19).

Methods: The subjects were randomly divided into two groups. The subjects were asked to open their mouth to make “ah” sound (traditional method) or simulate yawn (improved method) for throat swab collection. The usage of tongue depressor, collection time, adverse reactions and subjective discomfort (VAS score) were compared. The collection time, comprehensive indicators of adverse reactions and VAS score were also compared among three collectors.

Results: The tongue depressor was less used in the improved group ($\chi^2 = 40.186$, $P < 0.01$). The average collection time of the traditional group was 5.44 ± 2.97 and that of the improved group was 4.00 ± 2.31 ($P < 0.01$). The subjects in the improved group had fewer and milder adverse reactions. The VAS score of subjects in the improved group was lower than that in the traditional group ($P < 0.01$). Among different collectors, the collection time, comprehensive indicators of adverse reactions and VAS were the same as the overall trend.

Conclusion: Simulating yawn is a safer and faster throat swab collection method.

1. Introduction

The coronavirus disease 2019 (COVID-19) outbreaks rapidly at the end of 2019, and its strong infectivity and pathogenicity pose huge threatens to people's health and safety. Early prevention, diagnosis and treatment are of great significance for the prevention and control of COVID-19 [1]. Nucleic acid detection of COVID-19 is performed in nasopharyngeal swabs, sputum and other lower respiratory tract secretions, blood and feces [2] using reverse transcription-polymerase chain reaction (RT-PCR) or high-throughput sequencing [3]. Throat swab remains the major pathogen collection method owing to the advantages of relatively high detection rate, simple operation, less damage and mild discomfort symptoms. Traditional throat swab collection usually requires patients to slightly tilt their heads and open their

mouths to make “ah” sound. Tongue depressor is generally used when oropharynx is not clear. However, in the process of collection, opening the mouth may cause aerosol to eject from the patient's mouth along with the airflow, which increases the risk of infection in the surrounding population. Due to the stimulation of tongue base by tongue depressor, some patients may have different degrees of adverse reactions such as head dodge, hand resist, hiccup and cough, leading to collection failure. Coughing and vomiting produce a large number of aerosols and increase the risk of infection in the surrounding population. Therefore, we propose a new method for throat swab collection to solve the above problems. The improved method requires the subjects to simulate yawning so as to fully expose the oropharynx, which is more conducive to the efficient collection.

* Corresponding author at: Department of Urology, Tianjin Third Central Hospital, 83 Jintang Road, Hedong District, Tianjin 300170, China.

E-mail address: Chengfangming01511@163.com (F. Chen).

<https://doi.org/10.1016/j.amjoto.2020.102896>

Received 7 December 2020;

Available online 4 January 2021

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2. Materials and methods

2.1. General information

The patients who received nucleic acid detection of COVID-19 in the outpatient department of Tianjin Third Central Hospital from June 2020 to July 2020 were recruited in this study. Inclusion criteria: patients with normal cognitive behaviors. Exclusion criteria: patients with oral malformation, pharyngeal diseases, early pregnancy (within 13 weeks), late pregnancy (after 28 weeks), other diseases affecting inspiratory movement, such as liver cirrhosis, severe ascites, thoracic deformity, etc. A total of 1247 patients were included in this study. The patients were randomly divided into the traditional group (582 patients aged 11–86 years; mean 43.79 ± 17.38 years) and the improved group (665 patients aged 13–85 years; mean 43.54 ± 17.09 years). The general information of patients between the two groups was not statistically significant ($P > 0.05$). This study was approved by the Ethics Committee of Tianjin Third Central Hospital. Informed consent was obtained from each patients and their families.

2.2. Research methods

Throat swabs were collected by three specially trained collectors using the two methods. Patients in the traditional group opened their mouth and made “ah” sound when collecting throat swabs, as shown in Fig. 1A. Patients in the improved group simulated yawning when collecting throat swabs, as shown in Fig. 1B. Collection methods: the swab was applied from one tonsil to the other tonsil along the pharyngeal and palatal arch. The swab should touch the back wall of the throat and avoid touching the tongue. After three rounds of application, the swab head was quickly immersed in a disposable virus sampling tube (ST-II) containing 2 mL virus preservation solution. The tail was discarded and the tube cover was tightened. The tube was stored in a refrigerator at 4 °C. Collection site: outdoor or well ventilated place. Each patient should wear a mask during the whole process of collection. Before collection, the collection method should be explained to the patients. The air was disinfected immediately after collection. According to the requirements of personal protective equipment (PPE), the collector should wear a N95 mask, goggles, one-piece protective clothing, latex gloves, etc. [2].

2.3. Index observation and evaluation criteria

The usage of tongue depressor, collection time, adverse reactions (frown, cough, head evasion, hand block, tears, nausea or vomit etc.) and visual analogue scale (VAS) were compared. We defined the collection time as the time required from the entry of the throat swab into the mouth to the completion of the collection and leaving the oral cavity. According to the severity of adverse reactions, we assigned coefficients to various adverse reactions, called comprehensive indicators of adverse reactions. Mild symptoms, that is, Grade 1 reaction: frown, score 1 point. Moderate symptoms, that is, Grade 2 reaction: cough, head evasion, nausea, hand block, tears, recorded 2 points. Severe symptoms, that is, Grade 3 reaction: vomit, scored 3 points. The different collection methods were compared with the comprehensive indicators of adverse reactions. The collection time, comprehensive indicators of adverse reactions and VAS were compared among different throat swab collectors.

2.4. Statistical analysis

Data analysis was introduced using the SPSS 26.0 software. Data are expressed as mean \pm standard deviation ($\bar{x} \pm s$) and frequency/percentage (%). The t -test or χ^2 test was adopted for comparison between two groups. The $p < 0.05$ meant statistical significance.

3. Results

3.1. Comparison of the usage of tongue depressor between the two groups

Tongue depressor was used 506 times, accounting for 40.6% of the total number of subjects. The traditional group used the tongue depressor 291 times, accounting for 50.0%; the improved group used the tongue depressor 215 times, accounting for 32.3%. The frequency of tongue depressor usage in the traditional group was higher than that in the improved group, and the difference was statistically significant ($\chi^2 = 40.186$, $P < 0.01$).

3.2. Comparison of collection time and VAS between the two groups

The average collection time of the traditional group was longer than

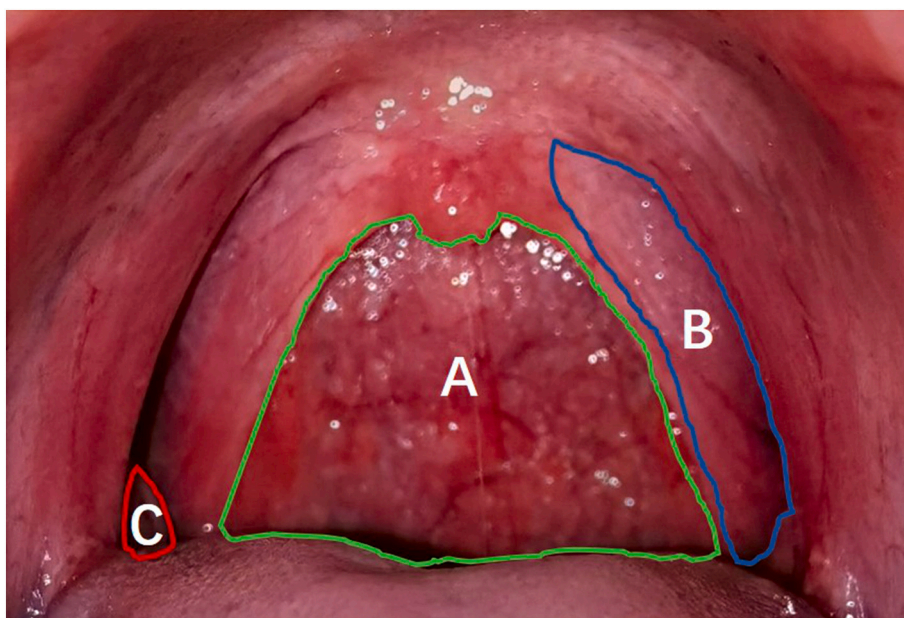


Fig. 1. Two throat swab collection methods. A: the traditional group. B: the improved group.

that of the improved group, and the difference was statistically significant ($P < 0.05$). The VAS score of the traditional group was higher than that of the improved group ($P < 0.05$), as shown in [Table 1](#).

3.3. Comparison of the incidence of adverse reactions between the two groups

Seven adverse reaction indicators were selected in the process of throat swab collection, including frown, head evasion, hand block, tears, cough, nausea and vomit. By comparing the adverse reactions caused by the two collection methods, it was found that the incidence of six adverse reactions (frown, head evasion, hand block, tears, cough and nausea) in the improved group were significantly lower than those in the traditional group ($P < 0.05$). There was no significant difference in the incidence of vomit ($P > 0.05$), as shown in [Table 2](#).

To further explore the overall relationship between different collection methods and various adverse reactions, we assigned coefficients to various adverse reactions according to the severity of adverse reactions. Mild symptoms, that is, Grade 1 reaction: frown, score 1 point. Moderate symptoms, that is, Grade 2 reaction: cough, head evasion, nausea, hand block, tears, recorded 2 points. Severe symptoms, that is, Grade 3 reaction: vomit, scored 3 points. By comparing different collection methods with the total score of adverse reactions, we found that the comprehensive score of 582 subjects in the traditional group was 2.53 ± 2.37 , and that of 665 subjects in the improved group was 1.24 ± 1.79 . The improved group had a lower average comprehensive score ($P < 0.01$), that is, fewer and milder adverse reactions occurred among the improved group during the collection.

3.4. Comparison of collection time, comprehensive score of adverse reactions and VAS score among different collectors

The collection time that the three collectors need was different, but the time of each collector using the traditional method was higher than that of the improved method ($P < 0.01$). According to the comprehensive score of adverse reactions calculated by the coefficient of severity of adverse reactions, the three collectors got lower comprehensive score of adverse reactions when using the improved method ($P < 0.01$). The three collectors produced lower VAS score when using the improved method ($P < 0.01$), as shown in [Table 3](#).

4. Discussion

Under the background of COVID-19 spreading rapidly worldwide, “early detection, early reporting, early diagnosis, early quarantine and early treatment” are decisive for controlling epidemic spread, reducing mortality and maintaining social stability. Rapid and effective etiological detection has become the most important link in “early detection” [2].

Throat swab or nasal swab is most commonly used in clinical practice. Hernes SS et al. have demonstrated that the positive rate of nasal swab is almost 19 times that of throat swab [4]. We speculate that such a difference may be related to the way of throat swab collection and the adverse reactions of patients during collection. The following conditions should be satisfied to make throat swab collection more effective: firstly, the pharynx should be fully exposed; secondly, the time of full exposure of pharynx should be as long as possible. However, the traditional throat

swab collection can not meet the above conditions, so we propose a new collection method, that is, let the patients simulate yawning during the collection.

Yawning can be divided into two steps: the first step is to open mouth and inhale quickly and the second step is to exhale slowly. During the first step, the oropharynx can be exposed to the maximum extent and maintained for a long time.

For the traditional collection method, the palatal arch is contracted inward and accompanied by the lifting of the tongue base when the “ah” sound is issued, leading to the narrowing of the gap between the palatal arch and the tongue and the difficulty in exposing the posterior pharyngeal wall. The inward contraction of the palatal arch is more likely to expose the tonsils, and thus “ah” sound is more suitable for tonsil examination, rather than throat swab collection ([Fig. 1A](#)). Hence, the traditional collection method is not conducive to the accurate collection of the secretion from posterior pharyngeal wall. For the improved collection method, the palatal arch is extended and uplifted with tongue base descending when the mouth is opened and inhaled rapidly. The posterior wall of the pharynx can be exposed to the greatest extent, and even part of the nasopharynx is exposed. Therefore, the improved method is more suitable for throat swab collection. Among the selected cases, 13 subjects still failed to collect under the condition of pronouncing “ah” and cooperating with tongue depressor, but the collection was successfully completed using the improved method. To improve the accuracy of detection, the swab should not touch the tongue during the collection process. The primary feature of simulated yawning is that it can fully expose the posterior pharyngeal wall, thus reducing the probability of swab touching the tongue ([Fig. 2](#)).

In terms of collection time, the improved group need shorter collection time than the traditional group ([Table 1](#)). The shortening of collection time shows the following advantages: 1. decreasing the exposure time of the patients and reducing the risk of infection in the surrounding population; 2. the improved method requires the patients to inhale the air flow inward, while the traditional method requires the patients to exhale the air flow outward, which also reduces the risk of infection in the surrounding population to a greater extent; 3. the number of people collected per unit time is increased, which improves the collection efficiency, shortens the waiting time, avoids crowd gathering and reduces the risk of infection.

Pharyngeal reflex is a normal and protective physiological mechanism. Vagus nerve is abundantly distributed in the base of tongue, soft palate, posterior pharyngeal wall and palatal lobe, which is manifested as nausea and vomiting caused by foreign body stimulating the posterior pharyngeal wall and tongue root [5,6]. According to the statistical data, there was no significant difference in age between the two groups ($P = 0.795$). The frequency of tongue depressor usage was compared, and the results revealed that the frequency of tongue depressor usage in the traditional group was higher than that of the improved group ($\chi^2 = 40.186$, $P < 0.01$). The improved method significantly reduced the usage of tongue depressor and alleviated the uncomfortable reactions caused by tongue depressor such as nausea and vomit, thereby impeding the generation of aerosol and reducing the risk of infection in the surrounding population.

The adverse reactions caused by the two methods were also compared. The adverse reactions included frown, head evasion, hand block, tears, cough, nausea and vomit. There were significant differences between the two methods in frown, head evasion, hand block, tears, cough and nausea ([Table 2](#)). Vomiting was the most serious adverse reaction in this experiment, and there was no significant difference between the two methods in vomiting. However, there were 4 cases of vomiting in the traditional group and 0 case in the improved group. If enough samples were added, there might be statistical difference. When the overall adverse reactions of different collection methods were compared, it was found that the comprehensive score of the traditional group was significantly higher than that of the improved group. The improved method produced fewer and milder adverse reactions than the

Table 1
Comparison of collection time and VAS between the two groups.

	Collection time (s)	VAS score
Traditional group (n = 582)	5.44 ± 2.97	2.58 ± 2.18
Improved group (n = 665)	4.00 ± 2.31	1.80 ± 1.97
t	9.61	6.64
P	0.00	0.00

Table 2
Comparison of the incidence of adverse reactions between the two groups.

	Traditional group	Improved group	Total	χ^2	<i>P</i>	<i>P</i> (adjust)
Frown	292	190	482	61.07	0.00	
Head evasion	141	66	207	45.86	0.00	
Hand block	30	6	36	20.02	0.00	
Tears	19	3	22	14.18	0.00	0.00
Cough	46	34	80	4.027	0.045	
Nausea	347	209	556	99.85	0.00	
Vomit	4	0	4	4.585	0.03	0.101

Table 3
Comparison of collection time, comprehensive score of adverse reactions and VAS score among different collectors.

	Collection time (s)		Comprehensive score of adverse reactions		VAS score				
	Traditional group	Improved group	<i>P</i>	Traditional group	Improved group	<i>P</i>	Traditional group	Improved group	<i>P</i>
Collector 1	4.37 ± 1.58	3.49 ± 1.68	0.00	2.50 ± 2.46	0.76 ± 1.48	0.00	1.66 ± 1.55	1.10 ± 1.27	0.00
Collector 2	4.28 ± 2.34	2.86 ± 1.38	0.00	2.02 ± 1.99	0.99 ± 1.51	0.00	2.47 ± 2.11	1.63 ± 1.93	0.00
Collector 3	7.98 ± 3.01	5.47 ± 2.68	0.00	3.07 ± 2.31	1.76 ± 1.88	0.00	3.39 ± 2.37	2.57 ± 2.25	0.00

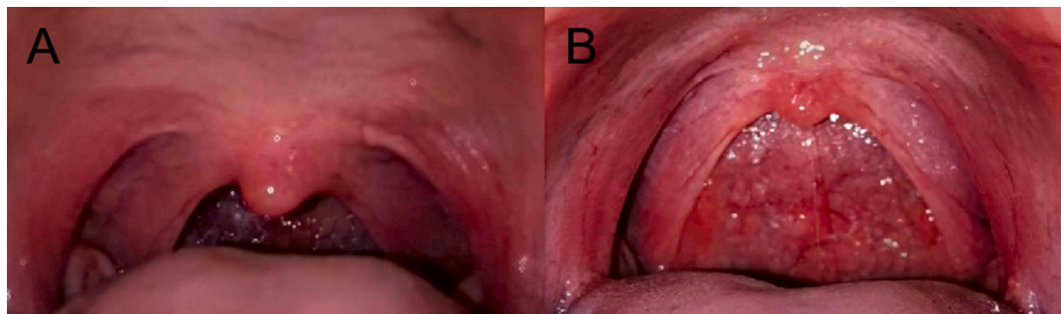


Fig. 2. Schematic diagram of pharyngeal structure: A: posterior pharyngeal wall. B: pharyngeal palatal arch. C: tonsil.

traditional method. After the throat swab collection, VAS was used to evaluate the degree of discomfort of patients. The results demonstrated that the VAS score of the subjects receiving improved method was lower ($P < 0.01$), which meant that the subjects were more likely to accept the improved method (Table 1).

To eliminate the experimental error caused by individual differences of collectors, three collectors participated in throat swab collection. The relationship between the two methods used by three collectors and the evaluation indexed were compared. The results revealed that the three collectors showed the same overall trend in terms of collection time, comprehensive indicators of adverse reactions and VAS score (Table 3). It was suggested that the above advantages of the improved method in pharyngeal swab collection were universal.

The subjects selected in this study were outpatients or routine virus screening patients, without epidemiological history, fever and respiratory symptoms. The prevention and control of the epidemic situation in this region was relatively optimistic, and there were no confirmed cases in recent days. The results of the COVID-19 nucleic acid detection of these subjects were negative, so this study failed to compare the two collection methods from the accuracy of nucleic acid detection, which became the regret of this study. We hope that we can cooperate with the epidemic prevention departments in the areas with severe epidemic situation, and evaluate the effect of the improved method on the detection of positive rate.

We propose a novel collection method, that is, to simulate yawning, which can expose the throat more fully and make the throat swab collection more safe and effective. The improved method not only alleviates the pain of patients caused by throat swab collection, but also reduces the risk of infection and the cost of collection. In addition, it also improves the confidence of collectors to a certain extent [7]. The

improved method contributes to obtaining pathogens more accurately and fully for nucleic acid detection, thus reducing the occurrence of false negative.

Funding

None.

Ethics approval and consent to participate

Our study involving human had signed informed consent. This study was designed in accordance with the Declaration of Helsinki and approved by the ethics committee of Tianjin Third Central Hospital.

Consent for publication

Not applicable.

Availability of data and material

Not applicable.

CRediT authorship contribution statement

Fangmin Chen finished study design, Minghao Zhang, Yujie Yang, Peng Qu, Yuchen Fan finished experimental studies, Minghao Zhang, Zhihao Niu, Xu Bao, Li Tian finished data analysis, Minghao Zhang finished manuscript editing. All authors read and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

Acknowledgement

We would like to acknowledge the reviewers for their helpful comments on this paper.

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