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Design of an air isolation and purification (AIP) desk for medical use and characterization of its efficacy in ambient air isolation and purification

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ABSTRACT

The incidences of nosocomial infections (NIs) are increasing throughout the world, especially for those airborne diseases caused by pathogens or air particulates that float in air. In this study, we designed and manufactured a desk for clinic consultation room air purification and air isolation between doctor and patient. The air isolation and purification (AIP) desk has a high efficiency particulate air (HEPA) filter on the tope and several primary efficiency filters on the sides for air purification. The air circulating between inlet and outlet forms a wind-curtain between doctor and patient. The Computational Fluid Dynamics (CFD) model was used to calculate the speed of the air flow and the angle of sampler. We tested the air purification function of the AIP desk in rooms sized about 3.6 × 2.8 × 2.8 m (L × W × H) and found that the AIP desk could significantly remove the tested air pollutants like smoke particulates and microorganisms like *Staphylococcus albus* (*S. albus*)and human adenovirus type 5 (HAdV-5). The wind-curtain can significantly block the exhale air of patient being transmitted to the respiratory area of doctor setting in the opposite of AIP desk. Thus, the AIP desk can be used in hospital setting to reduce the risk of NIs and protect both doctors and patients.

1. Introduction

Nosocomial infections (NIs), also called hospital-acquired infections, occur during hospitalization or after hospital discharge [1]. In developed countries, NIs affect 5%–10% of general hospitalized patients and up to 30% or more of intensive care patients [2]. Studies have indicated that this common complication currently affecting inpatients is a major biosecurity concern for patients and health care professionals worldwide [3–6]. NIs are usually caused by multidrug-resistant pathogens, and their appearance will result in extra healthcare costs to patients in terms of prolonged hospital stay and treatments, potential disability, or even death [7–9]. Respiratory viruses are one of the main pathogens that cause hospital-acquired infections [10,11]. For example, the severe acute respiratory syndrome coronavirus (SARS-CoV) was quickly transmitted within medical staffs, patients and visitors, caused severe additional suffering in China in 2003 [12]. The Middle East respiratory syndrome coronavirus (MERS-CoV) spread rapidly around the world, since the first case was confirmed in Saudi Arabia in June 2012. It is now found in 24 countries and regions, where it has a serious impact and causes huge financial losses [13–16].

In order to prevent and control NIs, it is vital for hospitals to take necessary procedures to isolate sources of infections and transmissions to ensure the quality of medical care and protection of vulnerable patients and medical personnel. Hand hygiene and personal protective equipment (PPE) are necessary straight forwards ways to prevent NIs and protect medical personnel. Air purifiers and central ventilation systems are further environmental preventative measures that may be employed. While proper ventilation can significantly reduce the amount of particulate matter and aerosols in air, limited space in some older hospital buildings render it impossible to install a central air supply system. Purification efficiency is also limited [17,18]. Furthermore, critically ill patients in traditional intensive care units (ICUs) are more susceptible to be infected via NIs as compared to patients in general [19].

We recently designed an air isolation and purification (AIP) desk integrated air isolation and air filtration/purification functions for the purpose of reducing hospital NIs. Computational fluid dynamics (CFD) model which usually used to assess the effectiveness of hospital ultraviolet germicidal irradiation devices and ventilation systems for the

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HIGHLIGHTS

Scientific question

Nosocomial infections (NIs) have always been an issue impacting public health. As far as COVID-19 epidemic in 2020 is concerned, there are 1,716 medical staff confirmed infected and at least 60 medical staff died in China. NIs are attracting more and more attention, but there have been no effective ways to prevent or reduce it.

Evidence before this study

Currently, disinfection of clinic rooms depends only on additional air purifiers or ultraviolet lamps, which is not only expensive and but also achieve only static disinfection.

New findings

We designed and manufactured an air isolation and purification desk (AIP desk) that integrates all the air isolation, filtration and purification functions into one equipment. Test results indicated that this desk can effectively reduce and remove particulate matter and pathogens in ambient air. The air circulating between inlet and outlet of AIP desk formed a wind-curtain that isolates patient's exhale air from doctor's respiratory area.

Significance of this study

The AIP desk can significantly reduce the risk of cross infection in the hospital, and thus effectively protecting patients and medical staff.

purpose of infection control [20–22] was adopted in the AIP desk. In this study, we used CFD simulation technology to determine the angle of sampler and the air supply speed of the AIP desk. Cigarette smoke, aerosolized bacteria *Staphylococcus albus* (*S. albus*) and human adenovirus type 5 (HAdV-5) were used to examine the purification efficiency of the AIP desk.

2. Materials and methods

2.1. Materials and equipment

S. albus was purchased from the Microbiology Institute of Guangdong (Guangdong, China). Cigarettes were purchased from a local shop (Hongtashan, Yunnan, China). A FA-1 type six-stage sieve percussive air microbial sampler (Shuohua, Jiangsu, China), spectrophotometer (Tsinghua, Shanghai, China), Y09-301 laser dust particulate counter (Sujing Instrument, Jiangsu, China), smoke generator and aerosol generator (Kangjie, Liaoning, China) were used to monitor the isolation efficiency of the test desk.

HAdV-5 is a stock of our laboratory. Adenoviruses were cultured in adenocarcinoma human alveolar basal epithelial cells (A549) that were obtained from the American Type Culture Collection (Manassas, VA, USA) and subsequently maintained in our lab. A549 cells were cultured in Dulbecco's Modified Eagle's Medium (DMEM) containing 2 μg/mL streptomycin and 10% fetal bovine serum (Invitrogen, Carlsbad, CA, USA). All cells were frozen using a BioFlash Drive commercial freezing kit (Fibulas, New York, NY. USA). HAdV-5 was purified using standard CsCl density gradient centrifugation. ABI7500 real-time PCR instrument were used to test the copies of virus (Thermofisher, MA, USA).

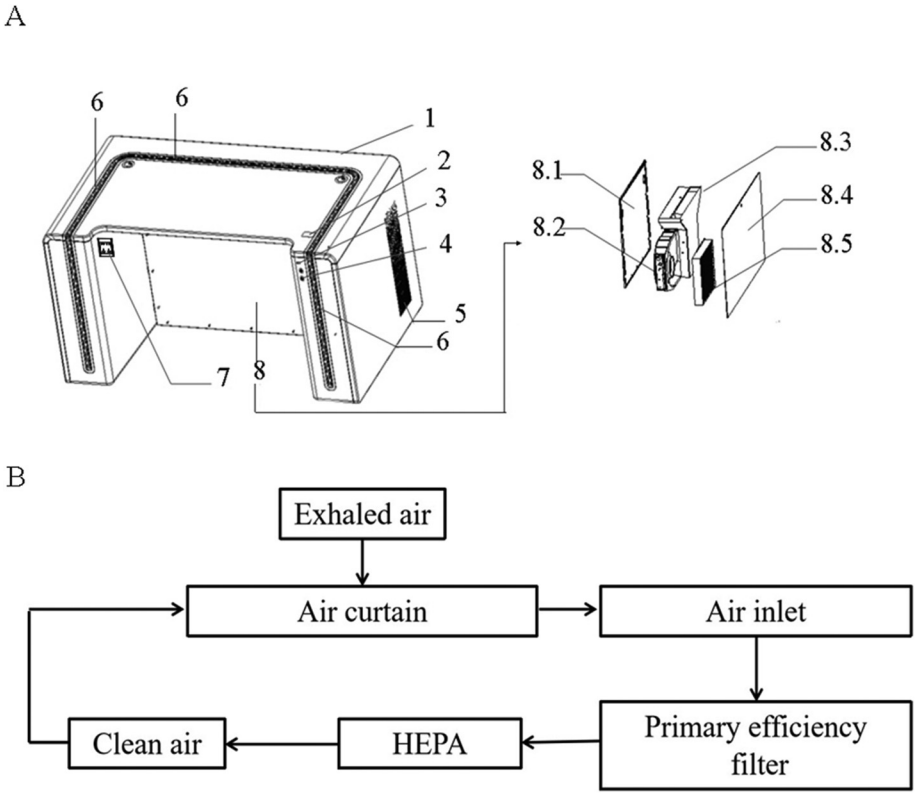

Fig. 1. Structure and function principle of the AIP desk. A: Structure (1: Shell; 2: Display; 3. USB; 4: Control; 5: Air inlet; 6: Air outlet; 7: socket; 8. Purification (8.1: Front shell; 8.2: Fan; 8.3: Air duct; 8.4: rear shell; 8.5: Filter). B: Schematic diagram of the operating principle of the AIP desk.

2.2. Structure and function principle of the AIP desk

The AIP desk was independently designed and developed by our team, and manufactured by Guangzhou Angel Biosafety Co., Ltd. The desk is 1.4 × 0.8 × 0.8 m (L × W × H) in dimension and detailed structure is showed in Fig. 1A. It is made of Acrylonitrile Butadiene Styrene and consists of two compartments: a desk and an air flow/filtration system which includes air inlets and outlets, air ducts, as well as purification filters. The control system is composed of display screen, switch buttons, USB interface and standard socket. The two inlets are located on each sides of the AIP desk to collect the ambient air and then purify it with filters. The purified air then comes out from air outlets location indicated in Fig. 1A, formed a wind-curtain air flow that blocks the respiratory air exchange between patient and doctor. The filter system contains primary efficiency filters on sides and a high efficiency particulate air (HEPA) filter on the top of the AIP desk.

A fan is installed at the position 8 indicated in Fig. 1A, and functions to drive air through the air ducts in the AIP desk. Upon the fan turned on, negative pressure is formed near the air inlets and sucks the surrounding air to pass through the air-ducts and filters; thereby physically remove pathogenic microorganism-containing aerosols and dust particulates in the adsorbed air. The filtered air then comes out of the air outlets and forms a wind-curtain barrier in front of patient and doctor; therefore, to block patient's exhale air to be transmitted over to doctor's respiratory area (Figs. 1A, 3A, B). Three gears are available for the wind speed of the AIP desk: high (3.0 m/s), medium (2.2 m/s), and low (1.8 m/s). Controls are those when the AIP des was turned off. The operating principle of the AIP desk is indicated by schematic diagram in Fig. 1B.

2.3. Experimental environment and setting of sampling sites

Two rooms with dimensions of 3.6 × 2.8 × 2.8 m (L× W × H) in our laboratory were used to conduct the experiment. The AIP desk was placed in the experimental room (Fig. 2 A1 and A2), and another room having a regular clinic desk served as control room. According to the five-point layout method [23,24], five sampling sites (A, B, C, D and E) as indicated in Fig. 2 B1 and B2 were selected. All the sampling sites were more than 1 m away from the wall, and were approximately 1 m high from the ground, which simulate the height of the patient's/doctor's mouth positions while sitting at each long side of the desk. The hydraulic diameter between the doctor's and the patient's mouths is 1.2 cm.

To facilitate the mesh division and ensure the quality of the mesh, the small air outlets of the air supply port were merged into one large air outlet, so the air supply area was simulated. It was larger than the data on the computer-aided design drawings but had little effect on the simulation results. There are 2 air outlet ports (28.0 × 9.5 cm, L × W) with a hydraulic diameter of 14 cm. Air supply angle θ refers to the angle between the direction of the air outlet in the length direction of the desktop and the normal

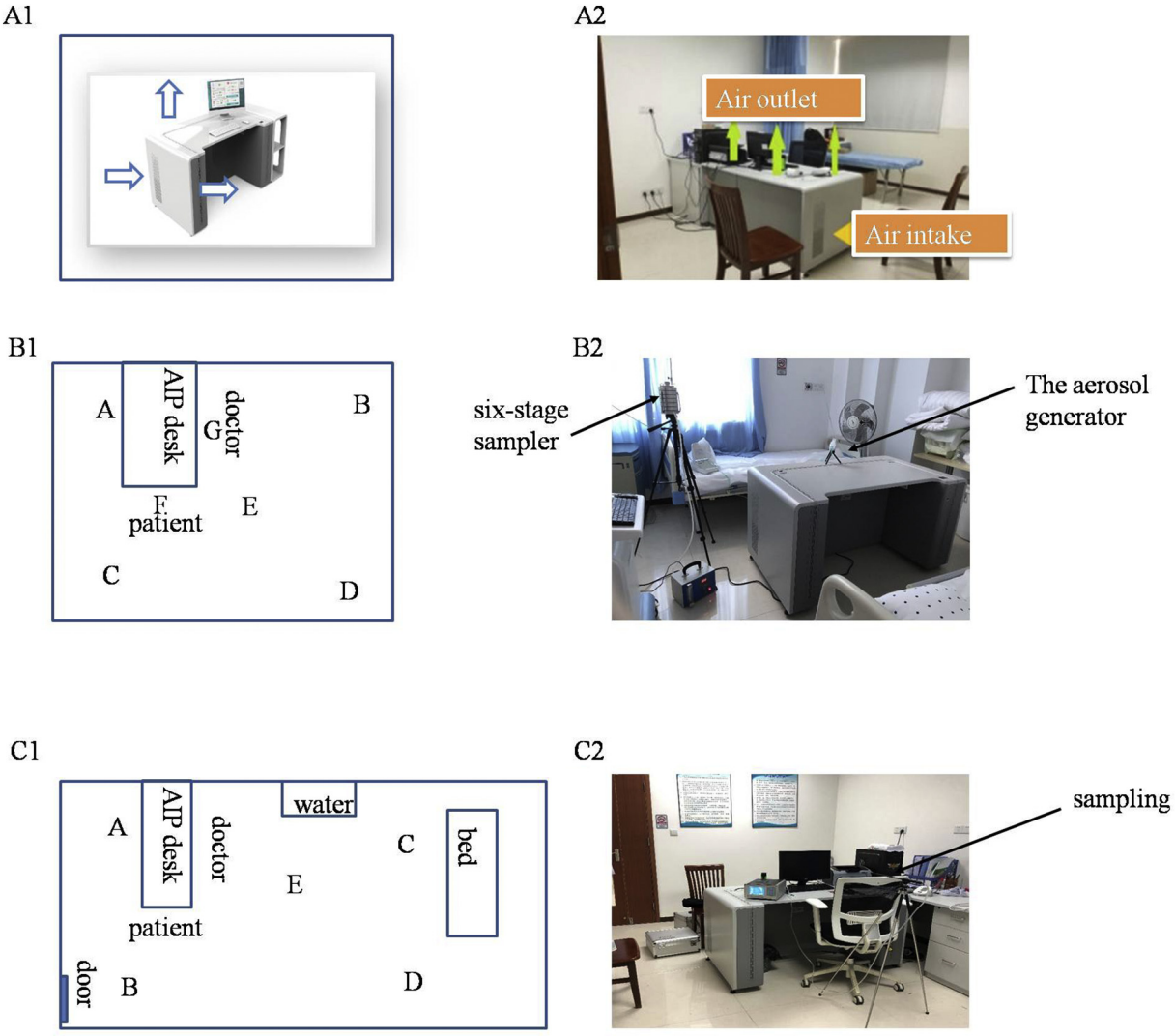

Fig. 2. Image of the AIP desk and sampling sites in laboratory and clinic experiments. A1: Image of the AIP desk; A2: Location of the AIP desk in test room; B1 and B2: Sampling sites in laboratory test room; C1 and C2: Sampling sites in clinic room.

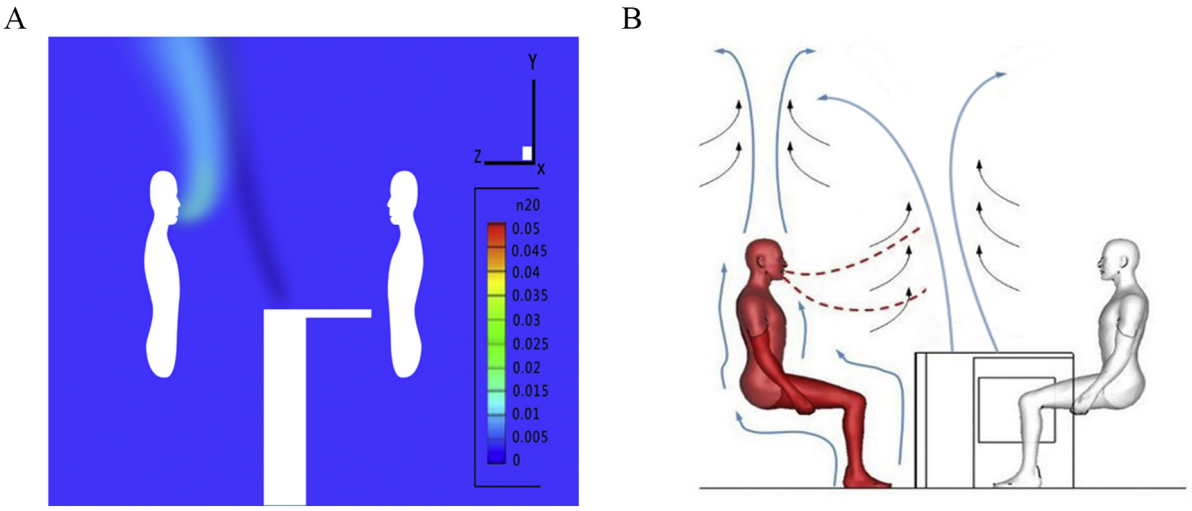

Fig. 3. Result of CFD model. A: Patient exhaled pollutant trajectory map (air supply angle θ is 20° and air supply speed is 3 m/s). B: Wind suction effect caused by wind-curtain jet and human thermal plume (angle θ is 20° and the air supply speed is 3 m/s).

direction of the desktop (Fig. 3A and B). The air supply speed refers to the air supply speed of the desktop with more air outlets. This simulation simplifies the patient's breathing state, considering only the patient's exhalation. All experiments were performed at 25–26 °C, with all the doors and windows closed and air conditioners turned off during the experiments.

Clinic experiments were conducted at Ruihe Chronic Disease Specialist Clinic in Guangzhou, Guangdong, China. We selected two clinic rooms of same size (3.6 × 4.3 × 2.8 m, L × W × H) and same orientation as indicated in Fig. 2 C1 and C2. One room was set up with the AIP desk, while the other room had a regular clinic desk. Five sampling sites (A, B, C, D and E, as in Fig. 2 C1) were selected. The temperature and humidity of the rooms were controlled at the same conditions of the laboratory experiments.

2.4. Experimental methods

2.4.1. Effects of AIP desk on removal of cigarette smoke particulates, S. albus and HAdV-5 contaminates

Background conditions within the test rooms were established by calibration of the ambient temperature to 25 °C, relative humidity to 55% ± 10% and total particulates concentrations to 1×10^4 particulates/L. A smoke generator was placed in the middle of the room and the test cigarette was then ignited. The cigarette was stopped when the initial concentration of smoke particulate reached 5.0 ± 1.0 mg/m^3. A standard ceiling fan was used to stir the air for 2 min to evenly mix the particulate contaminates with air in the test room. After the ceiling fan was turned off for 3 min, the concentration of particulates was measured using a laser dust particulate counter. The air purification desk was then turned on and allowed to run for 60 min, followed by measurement of the particulate concentration at the sites indicated (Fig. 2 B2). The procedure was repeated 3 times in each gear. Identical procedure was performed in the control room having a standard clinic desk.

Similarly, in the *S. albus* and HAdV-5 experiments, after calibrating the background conditions, an aerosol generator was used to generate the tested bacterial and viral aerosols for 15 min at the maximum atomization rate of 0.3 mL/min. Fan stirring was continued for 2 min after the mimic contamination phase was stopped, and the mixture was allowed to stand for 3 min. Bacterial sampling was performed at site E (Fig. 2 B1) using a six-stage sampler with a sampling time of 1 min, while viruses were sampled at site E using a virus sampler for 5 min. The air purification desk was then turned on for 15, 30 and 60 min respectively at each gear. Bacterial and viral samples were collected at each of the remaining sampling sites (Fig. 2 B1, B2, C1 and C2). These procedures were repeated in the control room.

The plates for *S. albus* collection were placed in an incubator and incubated at 37 °C for 24 h, then colonies formed were counted and the number of growing colonies (CFU/m3) were calculated. The gel membranes for HAdV-5 collection were respectively filled into virus culture solution, dissolved, mixed, and stored at 4 °C. An ABC nucleic acid extraction kit (Guangzhou Hexin Technology Co., Ltd.) was used for nucleic acid extraction of the samples. The number of viral genome copies was determined by real-time quantitative PCR (Q-PCR) using a universal adenovirus Q-PCR kit (Guangzhou Hexin Health Co., Ltd.) on Applied Biosystems 7500 real-time PCR system.

2.4.2. Efficacy of the wind-curtain blocking method

The sample to be tested was placed in the test room and the background conditions were established as described in Section 2.4.1. When the AIP desk was turned on, the fresh air from the outlet of the AIP desk will form a wind-curtain on the desk between the seating positions of a patient and a doctor. The background particulate concentrations surrounding doctor or patient were recorded using a laser dust particulate counter which can determine concentrations of particulates at diameters of 0.3, 0.5, 1.0, 3.0, 5.0 and 10 μm respectively. A cigarette was ignited, then placed near the aerosol generator and allowed to smoke continuously at patient's area (position F in Fig. 2B). Particulate concentrations at doctor's area (position G in Fig. 2B) and patient's area were simultaneously monitored using the dust counter. Air samples were taken every 5 min for total of 30 min.

In the virus isolation experiment, the virus generation sitewas set at the air inlet point F, where the corresponding virus concentration was used as the initial concentration. Other sites as A, B, C, D, E, and G are used as the experimental sampling sites. The low gear switch of the AIP desk and the virus generator were turned on simultaneously. A virus sampler (Millipore, USA) was used to collect at site F for 3 min at a flow rate of 50 L/min as the starting value, and then sample at the remaining sites for 3 min in every 15 min for a total of 30 min. The gel membranes collected at each site were respectively dissolved in virus culture solution, mixed, and stored at 4 °C. This method was repeated in the control room.

2.5. Air purification efficacy of AIP desk in a clinic room

In hospital clinic setting, the testing room was with an AIP desk while the control room has a regular clinic desk. Doors and windows were opened for 12 h to balance the air of the two rooms with the outside environment. Then doors and windows were closed, and ventilation

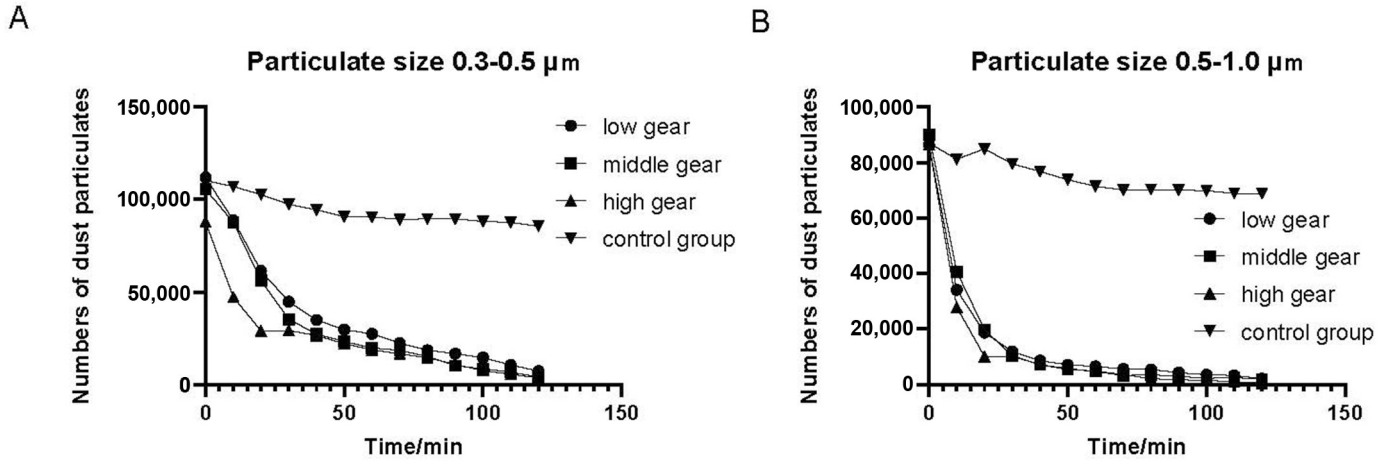

Fig. 4. Filtration purification of air smoke particulates by AIP desk at different gear positions.

system was turned off for 2 h to stabilize the air for detection of temperature and humidity. The mass concentration of dust particulates was measured, and the data collected were used as the initial concentration. The AIP desk was then turned on and data were recorded following the above-mentioned experimental procedure. Sampling was performed every 10 min for 2 h, with the sampling head being placed in position A, B, C, D and E (Fig. 2 C1 and C2).

2.6. Calculation and statistical analysis

Calculation formula used in this study is: Blocking rate: E' = (C0′- C1′) / C0′.

Note: C0′ is the average concentration at the initial point, and C1′ is the average concentration at each point around. We used SPSS 21.0 (IBM, Armonk, NY) for statistical analysis of the data and plotted the graphs using GraphPad Prism 8 (GraphPad Software, San Diego, CA). $P < 0.05$ was considered statistically significant.

3. Results

3.1. The result of CFD simulation technology

The air applying angle θ was set at 20° and the air distribution speed at 3 m/s where the supplying airflow formed a relatively complete wind-curtain, showed as dark blue in Fig. 3A. Study results indicated that patient's exhale air is blocked by the cold air flow emitted from the air outlet on the surface of the AIP desk, thus unable to cross over to the doctor's breathing area. The airflow around the doctor is not directly affected by the wind-curtain, and its thermal plume can develop normally. Thus, the wind-curtain from the AIP desk can block the airflow exchange between the patient and the doctor; thus, reduce the risk of aerosol infection of doctors.

The entrainment effect of the wind-curtain and the thermal plume of the human body is reflected in the simulation (Fig. 3B). Results indicated that when the air supply speed is at 3 m/s, and the air supply angle is 20°, the entrainment of the wind-curtain and human thermal plumes reached a better effect in the simulation. The suction effect generated by the wind-curtain plays a vital role in blocking the air transmission. The patient's exhale air will be drawn into the wind-curtain, then follow the air flow of the wind-curtain to the inlet of the desk for filtration and purification. Thereby the patient's exhale air was surrounded and controlled by the wind-curtain.

3.2. Efficacy of the AIP desk against cigarette smoke contamination

The air purification efficacy of the AIP desk in a contaminated room was assessed using cigarette smoke to simulate particulate pollution. The average values for five sampling sites in both the test and control rooms are shown in Fig. 4. The number of ≥0.3 μm particulates remained high throughout the experiment in the control group. However, with the presence of the AIP desk, the numbers of smoke particulates dropped rapidly

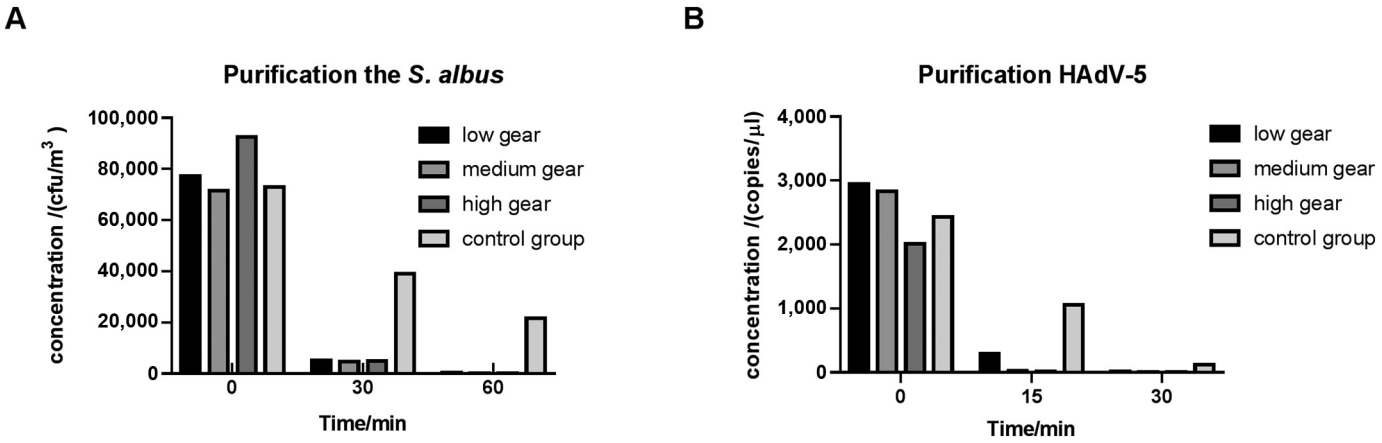

Fig. 5. Filtration purification of *S. albus*and HAdV-5 when AIP desk set at different gear positions. (A) Filtration purification of *S. albus* by running the AIP desk for 30 and 60 min respectively in the three gears; (B) Filtration purification of HAdV-5 by running the AIP desk for 15 and 30 min respectively in the three gears. Values are expressed as the mean of three replicates. ***$P < 0.01$.

Table 1
Smoke particulate (size ≥0.3 μm) blocking efficiency of AIP desk.

Time (min)	Blocking efficiency E' (%)			
	Control	High gear	Medium gear	Low gear
5	17.6	77.4	78.4	78.1
10	19.7	82.6	80.5	77.4
15	22.9	80.0	77.9	71.3
20	17.3	78.5	81.9	75.7
25	0.0	83.4	80.1	72.9
30	0.0	86.1	85.0	77.3
Average	13.0	81.3	80.6	75.4

Table 2
HAdV-5 aerosols blocking efficiency of AIP desk.

Time (min)	Blocking efficiency E' (%)			
	Control	High gear	Medium gear	Low gear
15	27.9	100.0	100.0	100.0
30	37.9	100.0	100.0	100.0
Average	32.8	100.0	100.0	100.0

from the first 30 min of the AIP operation, then almost 85.6% particulates have been removed when the AIP desk run for 60 min. The concentration of smoke particulates continued to decline until after 120 min when the target level was achieved. This was observed in all three gears/air flow speeds of the AIP desk (Fig. 4A and B). The results showed a significant difference between the control and the three experimental groups ($P < 0.01$). There were no significant differences in smoke particulate elimination among the high, medium and low gear settings of the AIP desk. Taken together, these data indicate that the purification desk has a high efficacy against particulate contamination in air.

3.3. Efficacy of AIP desk on decontamination of S. albus and HAdV-5

Air purification efficacy of the AIP desk was assessed in a room contaminated with aerosol pathogens, *S. albus* or HAdV-5. Results for *S. albus* removal showed a significant difference between the control and all the three experimental groups when AIP desk was run for 30 and 60 min respectively ($P < 0.01$) (Fig. 5A). There was no difference in purification efficiency among the groups with three different gears. No bacteria remained detectable in air after AIP desk was run for 60 min in all the low, medium and high gears.

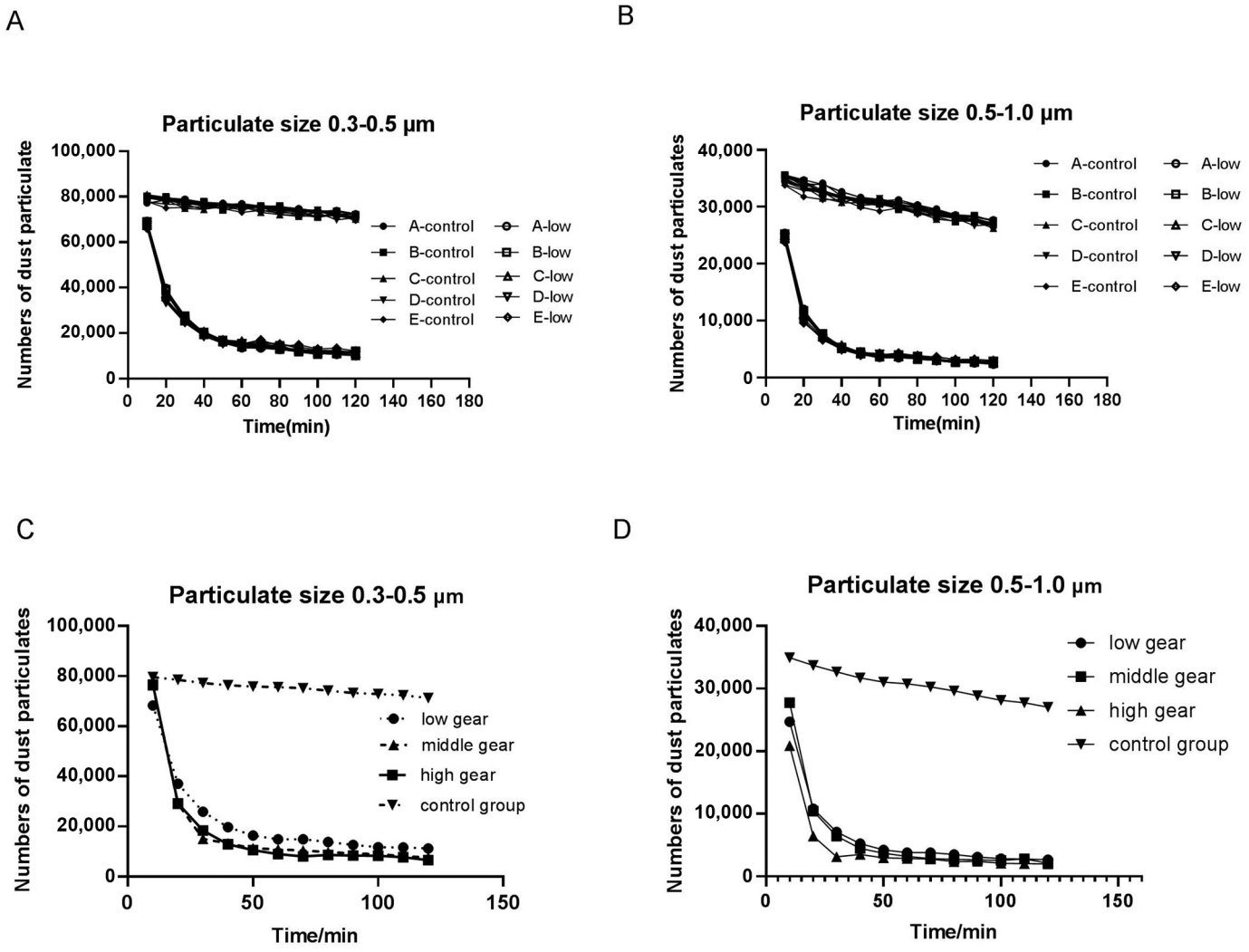

Fig. 6. Filtration purification of smoke particulates by AIP desk at different gear positions in clinic room. (A) particulate size at 0.3–0.5 μmin diameters with low gear and control group in clinic room; (B) particulate size at 0.5–1.0 μmin diameters with low gear and control group in clinic room; (C) particulate size at 0.3–0.5 μmin diameters in three gears and control group; (D) particulate size at 0.5–1.0 μmin diameters in three gears and control group.

As to the removal of HAdV-5, results showed a significant difference between the control and all the three experimental groups when AIP desk was run for 15 and 30 min respectively ($P < 0.01$) (Fig. 5B). There was no difference in purification efficiency among the groups with three different gears. No virus remained detectable in air after AIP desk was run for 30 min in all the low, medium and high gears. Thus, the AIP desk has extremely high purification efficacy against airborne pathogens.

3.4. Blockingefficacy of the AIP desk-produced wind-curtain

Cigarette smoke was used to simulate particulate contamination in patient's seating area and efficacy of the air wind-curtain in blocking these smoke particulates (patient's side) escaping to other side (doctor's side) was assessed. Results showed that the presence of the wind-curtain could significantly block the smoke particulates penetrating from the patient area to the doctor area (Table 1). When the AIP desk is set at the low gear and run for 30 min, the average blocking efficacy is 75.4%; when set at the high gear, the average blocking efficacy is 81.3%. Approximately 86.1% of the smoke particulates will be blocked when the AIP desk was run for 30 min at the high gear.

Table 2 shows the results of HAdV-5 blocking efficiency of the AIP desk. When used even at low air-flow gear, the HAdV-5 blocking rate reached 100% when AIP desk was run for 15 or 30 min respectively (Table 2), which means that HAdV-5 did not flow over to other side of the air-wind-curtain. HAdV-5 was not detected at all the sampling sites in the room, indicating that the isolation efficacy of the AIP desk is very good for removal of the virus.

Thus, the wind-curtain formed by AIP desk can effectively block smoke particulates and the aerosol pathogen from the patient's area to the doctor's area.

3.5. Efficacy of the AIP desk in a clinical setting

To assess the efficacy of the AIP desk in a clinical setting, we placed it in a functioning clinic consultation room. Fig. 6 showed the purification curve for experimentally contaminated smoke particulates. Results indicated that the number of particulates (0.3–1.0 μm and 0.5–1.0 μm) were decreased significantly (Fig. 6 A, B, C and D) after the AIP desk was run for 30 min at all three low, medium and high gears. Moreover, we found no difference in detected particulate concentration (data not shown) in all five sampling sites (Fig. 2 C1), demonstrating that the air purification efficacy is high in the clinical setting.

4. Discussion

Prevention of NIs is of vital importance for protection of both healthcare personnel and vulnerable patients, especial during the outbreak of infectious diseases, for example the currently on-going COVID-19 pandemics. The suddenness and rapid spread of the epidemics might result in insufficient PPE supply or PPE did not meet medical use standards. Medical personnel's unfamiliarity and irregularity with PPE operation, intensively increased workload make the implementation and monitoring of traditional disinfection and sterilization methods more difficulty [25]. In the study of McMichael et al. (2020) for epidemiology of COVID-19 in Washington, a total of 167 patients were confirmed, of which 50 were paramedics [25]. Some other studies have shown that respiratory viruses and some pathogens can be transmitted through droplets [26–28]. Therefore, development of novel technologies that can be applied in the clinic environment may represent a cost-effective means of reducing transmission of diseases.

In this study, we have described and tested a novel air isolation and purification (AIP) desk which we designed and manufactured by Guangzhou Angel Biosafety Co., Ltd. Concept of CDF model [20–22] was adopted in our design and we found that setting with air supply speed at approximately 3 m/s and the air supply angle θ at 20° gives the best droplet isolation efficacy ofthe AIP desk. We found that the AIP desk has a high purification effect following ambient air contamination by cigarette smoke, *S. albus* and HAdV-5. The air purification efficiency of the experimental groups (with an AIP desk) at all three wind speeds was consistently higher than that of the control group (with a standard medical consultation desk). Apparently, the AIP desk provides efficient air purification within the clinic consultation room and additionally protects healthcare personnel by means of a wind-curtain that separates them from patients.

Smoke particulates were used in this study as it is a representative air pollutant in China. The laser dust particulate counter we used in this study has the capacity to determine separately the concentrations of particulate sizes of 0.3, 0.5, 1.0, 3.0, 5.0 and 10 μm in diameters. Since there are very few particulates larger than 1 μm in smoke pollution; we then select to monitor only the concentrations of particulates at size ranges 0.3–0.5 μm and 0.5–1.0 μm. *S. albus* is also one of the standard airborne bacterial strain to test the performance of air purifier-related equipment in China. HAdV-5 is a DNA virus that causes respiratory diseases. It occurs mostly in children and can be fatal; therefore, it is meaningful to use it as test pathogen to detect the purification efficiency of our AIP desk. Moreover, in our laboratory, we have had the defective HAdv5, which will not cause human infection during the experiment and endanger the life and health of the experimental staff. The virus needs to be wrapped into particulates before spreading to the air [29]. The results of our experiments show that the use of the AIP desk can reduce the viral particulates in the air, and therefore reduce the time of the virus floating in the air. In addition, some studies have indicated that 1 m distance between people can effectively reduce the spread of droplets [30]. By using the AIP desk, we can shorten, when it is necessary, the distance between patient and medical staff due to the existence of the protective wind-curtain generated by the AIP.

Studies have shown that activities of on-site personnel during dynamic experiments have an impact on the concentration of pathogens collected and the concentration of respirable particulate matter, with more active people having a greater impact. Mechanisms to reduce the impact of the environment and personnel mobility will be the key improvement goal for dynamic purification equipment such as medical isolation clinics [31]. There are limitations on our experimental tests of the designed AIP desk because we only used smoke particulates, *S. albus*, and viruses to simulate the isolation of patient droplets. We did not truly test the isolation of patient droplets and the protection of medical personnel. Related experiments have been planned as our next step research.

The use of medical isolation clinics has played an important role in protecting medical personnel and reduce Nis [32]. Our AIP desk provides a new idea and method for future elimination of NIs risk. The medial equipment will fill the gap in dynamic medical air purification and provide technical support for dynamic air disinfection. Application of the AIP desk will enhance the control of airborne infectious disease, decrease the risk of NIs and the improvement to the safety of healthcare personnel.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

Author contributions

T. Liu did the experiment, data analysis and wrote the paper; Y. Guo, M. Wang, X. Hao and S. He did the exprement; R. Zhou designed the experiment and analyzed the data.

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