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Assessment of bacterial positivity rate changes in anesthesia machine internal circuits within recovery rooms and associated risk factors

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Abstract

Objective The objective of this study is to investigate bacterial proliferation within the internal circuits of anesthesia machines in post-anesthesia care units (PACUs) following the implementation of the new protocol, where 'a single dedicated external circuit is used for each individual patient.' This measure was introduced during the COVID-19 pandemic, in alignment with a novel prevention and control strategy.

Methods Using the observational technique, we analyzed anesthesia machines in PACUs between July and September 2022. The internal circuits of the anesthesia machines were disinfected every two weeks. Samples were obtained from the internal circuits on the 3rd, 5th, 7th, 10th, 12th, and 14th day following disinfection for bacterial culture. Changes in the positivity rate of bacteria in the internal circuits over time were analyzed using the generalized estimating equation. The anesthesia machines were divided into the positive group ($n=9$) and the negative group ($n=41$) based on the sampling results on the 14th day after disinfection. Risk factors for positive bacterial culture results in anesthesia machines in PACUs were analyzed using single-factor modified Poisson analysis and multi-factor modified Poisson regression analysis.

Results The positivity rates of the internal circuits of anesthesia machines in PACUs on the 3rd, 5th, 7th, 10th, 12th, and 14th day following disinfection were 10%, 14%, 12%, 20%, 16%, and 18% respectively. There were no statistically significant differences when the positive rates of the next five time points and the third day were compared ($P>0.05$). Risk factors for the contamination in the internal circuits of anesthesia machines was the number of elderly patients and the overall surgical use duration, with the difference was statistically significant ($P<0.025$).

Conclusion Amid the COVID-19 pandemic, characterized by the adoption of new prevention and control protocols, the disinfection interval for internal circuits of anesthesia machines in PACUs may potentially be extended. However, the emphasis of disinfection should still be placed on those anesthesia machines that have been used for a longer cumulative surgical duration and by a higher number of elderly patients over 60 years old. This approach ensures that resources are allocated effectively.

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Keywords Anesthesia machines, Bacteria, Disinfection, Post-anesthesia care units

Introduction

Contamination of breathing circuits of anesthesia machines can increase the incidence of postoperative lung infections in patients [1]. Bacteria such as Klebsiella pneumoniae and Stenotrophomonas maltophilia can form biofilms in endotracheal tubes and breathing circuits, which may lead to chronic, recurrent, and antibiotic-resistant lung infections in patients infected with bacteria that form biofilms through the airway [2, 3, 4]. Biofilm-producing organism are said to be associated with nearly 50% of the nosocomial infection [4]. With respect to contamination in anesthesia machine breathing circuits, McGain et al. [5] suggested that reusable external circuits be replaced after seven days, whereas Yang et al. [6] suggested that internal circuits of anesthesia machines be disinfected every seven days when respiratory filters are not used. Spertini et al. [7] found that there was no significant relationship between internal contamination and disinfection intervals in anesthesia machines when using filters between the endotracheal tube and the external breathing circuit, at the outlet and inlet of the anesthesia machine, and the external respiratory circuit was changed daily. The research results of Hartmann et al. [8] showed that the bacterial positivity rate of the breathing circuit after 72 h of use did not significantly increase compared to 24 h after use, when one person uses a respiratory filter and changes the external circuit once a day. The use of respiratory filters effectively reduces the contamination of anesthesia machines [7, 8]. The post-anesthesia care unit (PACU) serves as the primary area where the majority of post-operative surgical patients are transferred. As anesthesia machines in PACUs are utilized by a large number of patients, ensuring the prevention of contamination in these machines demands meticulous attention and specialized protocols [9]. Nowadays in response to the emergence of COVID-19, experts have advised the utilization of a single external respiratory circuit and respiratory filter in the anesthesia machine for each individual [10]. Respiratory filters and external breathing circuits of anesthesia machines used in PACUs are brought in from operating rooms. It is particularly important to study bacterial growth in the internal circuits of anesthesia machines under the new protocol, as well as to guide the disinfection of anesthesia machines in PACUs. Our hypothesis was that the bacterial positivity rate in the internal circuits of anesthesia machines in PACUs did not significantly change within one week following disinfection under the new protocol, but the bacterial positivity rate on the 9th to 14th day following disinfection was significantly higher than on the third day. Anesthesia machines in PACUs need to be disinfected again on the 9th to 14th day following disinfection. In this study we primarily examined changes in the bacterial positivity rate in the internal circuits of anesthesia machines in PACUs over a two-week period and investigated factors influencing bacterial growth in the internal circuits, as reported below.

Data and methods

Study material and general data

This study was an observational study that did not employ blinding or randomization methods. The study was carried out on all 9 Ohmeda anesthesia machines being used in the PACUs of the First Affiliated Hospital with Nanjing Medical University from July to September 2022. These machines have already been in use for 6 to 8 years. Anesthesia machines with positive bacterial culture results immediately after disinfection, as well as those used on patients with recent respiratory illnesses or an infectious disease history, were immediately disinfected and excluded from the study. During the study, anesthesia nurses in the PACU pay attention to the principle of sterility and timely hand hygiene in their work. Monitors, surface of anesthesia machines, computers, office desks, rescue vehicles, etc. were wiped daily with Cornell wet wipes. Two air purifiers were used in the PACU. The temperature of the PACUs was maintained at 24–26 °C, and the humidity was maintained at 40–50%. The internal circuit of the anesthesia machine includes the air inlet port, the air outlet port, bellows, soda lime canister, APL valve, and the air reservoir bag port. The external circuit of the anesthesia machine includes a threaded tube and an air reservoir bag. Components of the external breathing circuits of the anesthesia machines, including threaded tubes, respiratory filters, masks, and air reservoir bags, were brought into the PACUs from the operating rooms. Each set of components was used for only one individual and was discarded after use. The respiratory filter was placed between the threaded tube and endotracheal tube.

Anesthesia machines in PACUs were disinfected every two weeks using a machine dedicated to the disinfection of the internal circuits of anesthesia machines. Samples were taken from the internal circuits of the anesthesia machines immediately after the disinfection and then again on the 3rd, 5th, 7th, 10th, 12th, and 14th days after the disinfection. Three months of this cycle were completed, yielding 300 samples and a total of 50 instances of PACU anesthesia machine data.

During the study, 50 PACU anesthesia machines in all served 1,722 patients. We recorded the following data for each anesthesia machine: the total number of patients who used the anesthesia machine, the number of elderly

patients who were over 60 years old and used the anesthesia machine, the number of patients who underwent laparoscopic surgery and used the anesthesia machine, the number of patients who were in a lateral or prone position during surgery and used the anesthesia machine, and the total surgical duration. This study was approved by the ethics committee of the First Affiliated Hospital with Nanjing Medical University (Approval number: 2022-SR-246).

Disinfection methods of the anesthesia machines

The disinfection machine used in this study was provided by Shengning Biotech Co., Ltd., Tianjin City, and was dedicated to disinfecting the internal circuits of anesthesia machines and ventilators. The product specification was SN-803-B4. The disinfectant utilized was an alcohol-based compound disinfectant supplied by Shengning Biotech Co., Ltd., Tianjin City.

The disinfection machine was used in the following ways: (1) Remove the manual air reservoir bag and seal it with silicone plugs; (2) Open the adjustable pressure-limiting valve (APL) to the maximum value; (3) Switch the machine to the manual ventilation mode; (4) Empty the soda lime and put it back into the soda lime canister; (5) Connect the air inlet and outlet of the disinfection machine to the air outlet and inlet of the anesthesia machine, respectively. (6) Select the regular disinfection mode. The diaphragm should vibrate during normal operation of the machine.

The disinfection in the PACUs was carried out every two weeks on Fridays after work. Anesthesia machines were used normally for two weeks after they had been disinfected.

Sampling methods

Bacterial sampling in this study was conducted at the following sites of the anesthesia machines: The sites of the internal lining of the circuits, 3 cm away from the air inlet end, the air outlet end, and the interface end of the air reservoir bag. The area of bacterial sampling is a total of 49cm^2. The sampling method: All anesthesia machines will start sampling and processing at 17:00 on the sampling day, with a total duration of approximately 1 h. A sterile normal saline-soaked swab head was used to perform the sampling, simultaneously collecting samples from the anesthesia machine's three sampling sites. Then, put the swab head into 10 mL of sterile normal saline, mix well, and take 0.2 mL to inoculate onto Nutrient agar (Zhengzhou Antu Bioengineering Co., Ltd, Zhengzhou, China). Finally, the dishes were incubated in a 37 °C incubator for 48 h. Pay attention to the principle of sterility during the sample collection process.

Criteria for interpreting bacterial culture results

Bacterial growth was observed after the samples had been cultivated for 48 h. Use the flat colony counting method for colony counting. Based on national standards for hospital hygiene disinfection criteria: the total number of bacterial colonies in the internal circuit of the anesthesia machine should be ≤20CFU/cm^2, and no pathogenic bacteria should be detected [11]. If there is no bacterial growth, the result of bacterial culture in this anesthesia machine is negative and the anesthesia machine does not need to be disinfected. If the total number of bacterial colonies in the internal circuit of this anesthesia machine is >20CFU/cm^2, the result of bacterial culture in this anesthesia machine is positive and the anesthesia machine must be disinfected. If the total number of bacterial colonies in the internal circuit of this anesthesia machine is 1-20CFU, the result of bacterial culture in this anesthesia machine is positive, and it is necessary to determine whether disinfection is needed based on the presence of pathogenic bacteria.

Statistical analysis

This study is an exploratory study, and there is no previous study on contamination of anesthesia machines in PACUs under the new mode. We refer to the research results of Wang Xuefu and spertini, who have different modes but use respiratory filters. The results of Wang et al. [12] showed that the positive rate of bacteria was 3.85% on the 11th day after disinfection. Spertini et al. [7] showed that bacterial culture results were negative during 1–15 days after disinfection. Therefore, considering the previously low positive rate, we chose to try our best to collect the largest sample size. In this study, all 9 Ohmeda anesthesia machines in PACU were included in the study group. In terms of research time, in order to make the research results more secure for patients, we chose the summer with the highest incidence of gram negative bacilli closely related to pneumonia [1, 13, 14]. Finally, a total of 50 anesthesia machines and 300 bacterial culture results were collected.

The database was created in Excel and the statistical analysis was carried out using the SPSS 25.0 software. Data from normally distributed enumeration data are reported as mean±standard deviation ($\bar{x} \pm s$). The median (quartiles) (M [*P25*, *P75*]) were used to represent non-normally distributed enumeration data. The generalized estimating equation was used to test data from enumeration and data from repeated binary measurements, with statistical significance defined as ($P<0.05$). Risk factors were first analyzed using single-factor modified Poisson regression, and then independent variables with $P<0.2$ are included for multi-factor modified Poisson regression analysis, with statistical significance defined as ($P<0.025$).

Table 1 Characteristics of patients used anesthesia machines within two weeks after disinfection

Variables	Positive group (n = 9)	Negative group (n = 41)	All (n = 50)
Number of patients (case)	42(28,52)	32(19.5,50)	34.5(20,50.25)
Number of female patients (case)	25(16.5,31)	19(11.5,30)	20.5(12,30)
Number of male patients (case)	17(11.5,21)	13(8,20)	14(8,20.25)
Number of patients with body mass index greater than 24 (case)	15(10.5,19)	10(6.5,19)	12.5(7,19)
Number of patients who were over 60 years old (case)	6(4.5,9)	4(2,5)	4(2,5.25)
Number of patients who underwent laparoscopic surgery (case)	6(5.5,10)	5(2,9)	5(2,9)
Number of patients who were in a lateral/prone position during surgery (case)	14(9.5,18.5)	9(5,16)	9(5,17)
Total surgical duration (min)	3540 (2997.5,4120)	2070 (1175,3805)	2512.5 (1420,3837.25)

Results

Statistics related to the use of anesthesia machines in PACUs and bacterial positivity rate

The anesthesia machines were divided into the positive group (n=9) and the negative group (n=41) based on the sampling results on the 14th day after disinfection. Table 1 shows the characteristics of patients in positive group, negative group and all anesthesia machines. Figure 1 shows the statistics related to the cumulative patient usage per anesthesia machine in the PACUs from the day of disinfection to the day of recording data, as well as changes in the positivity rate of bacteria in the internal circuits of the anesthesia machines over time. After the sampling immediately following disinfection was removed, a total of 300 samples were collected. Out of 300 samples, a total of 45 results of bacterial culture were positive. The overall positivity rate was 15%, while areas with no bacterial colonies exceeded 20 CFU/cm^2. The positivity rate was lower on the 7th and 12th days following disinfection than on the 5th and 10th days, respectively.

Changes in the positivity rate of bacteria in the internal circuits of anesthesia machines in PACUs

The positivity rate of the internal circuits of the anesthesia machines on the 3rd, 5th, 7th, 10th, 12th, and 14th days following disinfection, was 10%, 14%, 12%, 20%, 16%, and 18%, respectively. There were no statistically significant differences when the positive rates of the next five time points and the third day were compared using the generalized estimating equation (Table 2).

Analysis of risk factors of bacterial growth in the internal circuits of the anesthesia machines

We use the result (positive or negative) of bacterial growth in the anesthesia machines in PACUs on the 14th

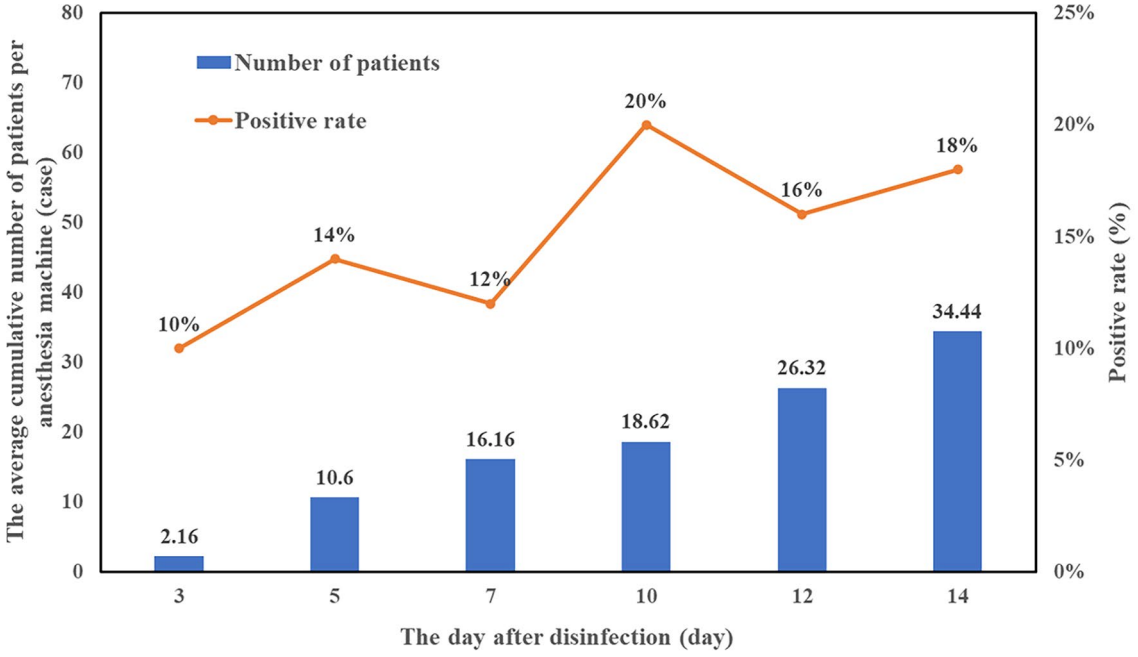

Fig. 1 Changes in the positivity rate of bacteria in the internal circuits of anesthesia machines at different time points within two weeks following disinfection

Table 2 Comparison of the positivity rate of bacteria at different time points

Parameter	β	$s\ \bar{x}$	95% confidence interval		Hypothesis testing	
			Lower limit	Upper limit	Waldχ2	*P* value
14th day following disinfection	0.681	0.540	0.686	5.692	1.590	0.207
12th day following disinfection	0.539	0.598	0.531	5.537	0.812	0.368
10th day following disinfection	0.811	0.635	0.649	7.805	1.633	0.201
7th day following disinfection	0.205	0.680	0.324	4.651	0.091	0.763
5th day following disinfection	0.382	0.605	0.447	4.797	0.398	0.528
3rd day following disinfection	0[a]					

Note a: Reference group β: regression coefficient $s\ \bar{x}$: Standard error

Table 3 Single-factor modified Possion regression analysis of risk factors of contamination in the internal circuits of anesthesia machines in PACUs

Variable	β	$s\ \bar{x}$	Wald	*P* value	RR value	99%CI
Number of patients using anesthesia machine	0.022	0.017	1.727	0.189	1.023	0.979 ~ 1.068
Number of patients who were over 60 years old and used anesthesia machine	0.295	0.090	10.674	0.001	1.343	1.064 ~ 1.694
Number of patients who underwent laparoscopic surgery and used anesthesia machine	0.050	0.040	1.583	0.208	1.051	0.949 ~ 1.164
Number of patients who were in a lateral/prone position during surgery	0.041	0.025	2.697	0.101	1.042	0.977 ~ 1.111
Total surgical duration	0.001	0.000	18.331	0.000	1.001	1.000 ~ 1.001

Note β: regression coefficient $s\ \bar{x}$: Standard error; RR: Relative Risk; CI: Confidence interval

Table 4 Multi-factor modified Possion regression analysis of risk factors of contamination in the internal circuits of anesthesia machines in PACUs

Variable	β	$s\ \bar{x}$	Wald	*P* value	RR value	99%CI
Number of patients using anesthesia machine	-0.053	0.035	2.327	0.127	0.949	0.868 ~ 1.037
Number of patients who were over 60 years old and used anesthesia machine	0.308	0.123	6.272	0.012	1.361	0.991 ~ 1.868
Number of patients who were in a lateral/prone position during surgery	-0.147	0.071	4.295	0.038	0.864	0.720 ~ 1.036
Total surgical duration	0.001	0.000	11.260	0.001	1.001	1.000 ~ 1.002

Note β: regression coefficient $s\ \bar{x}$: Standard error; RR: Relative Risk; CI: Confidence interval

day as the dependent variable, and conduct a single-factor Poisson regression with the following as independent variables: the number of patients using the anesthesia machine, the number of patients who were over 60 years old, the number of patients undergoing laparoscopic surgery, the number of patients in lateral/prone position during surgery, and the total surgical time of patients using the anesthesia machine (Table 3). And then variables with a single-factor modified Poisson analysis result of ($P<0.2$) are included for multi-factor modified Poisson regression analysis, with statistical significance defined as ($P<0.025$). The findings revealed that for every one-minute increase in the overall surgical duration of patients who used an anesthesia machine in a PACU, the risk of a positive result of bacterial culture in this anesthesia machine increases by 0.001 times and for every additional patient over 60 years old who used an anesthesia machine in a PACU, the risk of a positive result of bacterial culture in this anesthesia machine increases by 0.361 times (Table 4).

Discussion

Characteristics of this study

This study observed and analyzed the contamination status of anesthesia machines in PACUs within two weeks post-disinfection. Prior related research primarily focused on anesthesia machines in operating rooms [5–8]. PACUs serves as the location for postoperative anesthesia recovery and tracheal extubation for the majority of surgical patients throughout the hospital except for those who cannot be safely extubated and need to go to the intensive care unit, making its contamination impact extensive and highlighting the paramount importance of disinfection of anesthesia machines [15]. Consequently, this study selected anesthesia machines in PACUs as the subject of investigation. During the patient's awakening phase, there are significant fluctuations in airway pressure, whereas the operating room primarily serves as the site for anesthesia induction and surgical procedures for patients within this room. During the anesthesia maintenance phase, airway management is relatively stable, which may potentially lead to greater contamination of anesthesia machines in PACUs compared to those in operating rooms. Furthermore, earlier literature

suggested a disinfection interval of 7 days for anesthesia machines in operating room without respiratory filters [6]. Subsequently, research has found that respiratory filters can effectively reduce contamination of anesthesia machines [7, 8]. In this study, both the external breathing circuits and respiratory filters of the anesthesia machines were used once per patient and discarded afterward. This practice ensures a higher level of sterility compared to previous studies conducted under the mode of non-use of respiratory filters or reuse of respiratory filters and external breathing circuits. These characteristics introduce unknown variations in the contamination of anesthesia machines in PACUs.

Changes in the positivity rate of bacteria

As indicated by the results of this study, within two weeks of use after disinfection, the positivity rate of bacteria in anesthesia machines in PACUs fluctuated between 10% and 20%. The positivity rate of bacteria did not significantly increase with increase in the number of days of use within two weeks of using the anesthesia machines in PACUs following disinfection in the internal circuits. In the same period, there was also no significant increase in the positivity rate between the 3rd and the 14th days of use. It was also observed that there were bacterial cultures turning from positive to negative in the anesthesia machines, with the positivity rate on the 7th and 12th days after disinfection being lower than the positivity rate on the 5th and 10th days. Hartmann et al. [8] also found that the bacterial positivity rate of anesthesia machines was lower at 72 h after disinfection than at 48 h, which is similar to the results of this study. Some studies have indicated that the disinfection interval for the breathing circuits in anesthesia machines in specific usage scenarios is 7 days [5, 6]. However, based on findings in this study, when a single external circuit and respiratory filter of the anesthesia machine is used for each individual, contamination of PACU did not signifcantly increase within two weeks. Moreover, 85% of the bacterial cultures in two weeks were negative, suggesting that re-disinfection was not necessary. Only 15% of the bacterial cultures were positive, and the total number of colonies was <20, suggesting that disinfection was not necessary unless there were pathogens. Therefore, unless the anesthesia machine was used by patients with recent respiratory illnesses or an infectious disease history, perhaps the disinfection interval of the anesthesia machine can be extended. This is also consistent with the research findings of Spertini et al. [7]

Using one external circuit and respiratory filter in anesthesia machines in PACUs exclusively for a specific individual significantly lowers the risk of bacterial contamination in the external circuits of anesthesia machines, thereby avoiding contamination in the internal circuits [16]. The bacterial contamination rate of the anesthesia machine on the 26th day after disinfection was only 2.17% when using a respiratory filter, as shown by the research results of Wang et al. [12] Dubler et al. indicated that there was no significant increase in the positivity rate of bacteria in the internal respiratory circuit of the anesthesia machine on the 7th day as compared to the 1st day when the external respiratory circuit and filter were reused [17].

This following is related to the working modes of PACUs: (1) Patients in PACUs need to undergo endotracheal and oral suctioning under brief deep anesthesia unless contraindicated, which greatly reduces the source of contamination in the anesthesia machines' internal breathing circuits [18, 19]. (2) Patients in PACUs have a fast turnover in using anesthesia machines and a short duration of mechanical ventilation using endotracheal tubes. (3) High-flow ventilation is used in PACUs in conditions such as scavenging of anesthetic gases and unstable respiratory circulation in patients after extubation [20, 21]. Under high-flow ventilation, the essential temperature and humidity for bacteria in the internal circuits of anesthesia machines cannot be maintained [22, 23]. Furthermore, studies show that increasing the fresh air flow, decreasing the amount of carbon dioxide that needs to be filtered by soda lime, and decreasing the generation of calcium carbonate from soda lime can maintain the self-sterilizing effect and provide a strong filtering and sterilizing effect, lowering the bacterial levels in the breathing circuit [23–25]. As a result, in this investigation, the switch from positive to negative bacteria culture findings was found in some anesthesia machines.

It is uncertain whether the reuse of disinfection machines leads to cross-contamination or the growth of drug-resistant bacteria in the internal circuits of anesthesia machines. Disinfecting the internal circuits is time-consuming and labor-intensive, and repeating the disinfection when the bacterial positivity rate is low would squander medical resources and increase the department's disinfectant and soda lime costs. Therefore, unless the anesthesia machine was used by patients with recent respiratory illnesses or an infectious disease history, our results might rather support an extension of re-disinfection intervals. when the practice of exclusive use of one external respiratory circuit and respiratory filter of the anesthesia machine for a specific individual is adopted in the PACU.

Analysis of risk factors of contamination of anesthesia machines

Age, laparoscopic surgery, surgical time, prone position, and lateral position are risk factors for contamination in the circuits of anesthesia machines in operating rooms when respiratory filters are not employed, according

to research findings by Yang et al. [26] In this study we examined the effects of the number of patients using anesthesia machines in PACUs, the number of patients who were over 60 years old and used anesthesia machines in PACUs, the number of patients who underwent laparoscopic surgery and used anesthesia machines in PACUs, the number of patients who were in a lateral or prone position during surgery and used anesthesia machines in PACUs, as well as the effect of the total surgical duration on the 14-day bacterial positivity rate of anesthesia machines in PACUs. According to the findings of the multi-factor modified Poisson regression analysis, the surgery duration of patients and the number of elderly patients are risk factors for contamination of internal circuits of anesthesia machines in PACUs. Airway pressure will continue to increase during laparoscopic surgery and prone surgery. This will lead to restrictive ventilation dysfunction and mucosal damage in patients, resulting in lung immune system response, increased secretion, and sputum formation. The internal circuit of the anesthesia machine in the operation room is more vulnerable to contamination. However, both laparoscopic surgery and surgical posture occur only for a period of time during the operation, and the anesthesia nurse will suction sputum in time after the patient enters PACU. Therefore, the operation position and laparoscopic operation formula have a significant impact on the contamination of anesthesia machines in the operation rooms, but not in PACUs. Longer surgical duration and more elderly patients will significantly aggravate the contamination of anesthesia machines in PACUs and operation rooms. On the one hand, lengthy operations foster a more hospitable environment for bacterial development in the respiratory circuit, including temperature and humidity, which exacerbates the growth of germs in the external circuits of anesthesia machines in the operating rooms. On the other hand, patients bring external breathing circuits utilized in the operating rooms into PACUs. As the patients breathe in PACUs, airflow from the external circuits of the anesthesia machines enter their internal circuits. This exacerbates the contamination in the internal circuits of anesthesia machines in PACUs. At the same time, the organ functions of the elderly undergo degenerative changes, with impaired gag reflex, decreased mucociliary function, and increased secretions during surgery and the recovery period of anesthesia, which are more likely to contaminate the anesthesia machine [27]. Therefore, when disinfecting anesthesia machines in PACUs, it is advisable to prioritize disinfecting the internal circuits of anesthesia machines that have been used for a longer cumulative surgical duration or have been used by a higher number of elderly patients over 60 years old, as this can effectively reduce the incidence of contamination in the anesthesia machines.

Limitation and outlook

This study has certain limitations. This study did not detect pathogenic bacteria and viruses, nor did it carry out the cultivation of anaerobic bacteria, which makes this study unable to give a specific disinfection time interval, and can only give exploratory disinfection suggestions. On the basis of this study, it is suggested that the precise effective period after each disinfection should be further studied by lengthier experimental cycles based on the detection of pathogenic bacteria and viruses. At the same time, it is advised that the bacterial communities that contaminated anesthesia machines and were linked to patient respiratory tract infections and hospital postoperative infections be investigated further. This will enable the selection of more effective disinfectants targeting the relevant bacterial communities. Thus, it can provide a set of disinfection guidance scheme that is both safe and efficient, while taking into account cost savings, labor reduction and time optimization.

Conclusion

In summary, the internal bacteria of anesthesia machines in PACUs under the new protocol are not significantly and continuously growing. Our results might rather support an extension of re-disinfection intervals. However, prioritizing disinfection of anesthesia equipment that have been in use for lengthier surgical durations or have been used by a higher number of elderly patients over 60 years old is still advised. This approach optimizes departmental resources and effectively reduces the bacterial positivity rate in anesthesia machines within PACUs.

Abbreviations

PACU Post-anesthesia care unit
APL Adjustable pressure limiting

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Author contributions

Zhang SX and Li TL conceived the idea and conceptualised the study. Li TL, Ji YH, Hong JJ and Xu WS collected the data. Ge JW and Zhou XL analysed and interpreted the data. Zhang SX, Hong JJ, Ji YH and Xu WS statistically analyzed the data.Zhang SX drafted the manuscript. Zhou XL and Ge JW reviewed the manuscript. All authors read and approved the final draft.

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Data availability

The datasets analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted with approval from the Ethics Committee of the First Affiliated Hospital with Nanjing Medical University (Approval number:

2022-SR-246). This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

Informed consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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