

INVESTIGATION OF THE EFFECT OF A DISPOSAL ENDOTRACHEAL CATHETER AND METAL CATHETER COMBINATION APPLICATION IN INHALATION INJURY PATIENTS

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SUMMARY. *Objective.* The aim of this paper was to make an objective evaluation of the scientific nature and effectiveness of a combination application of two catheters by investigating and comparing the effects and the occurrence of complications using a single metal catheter application, a single disposal endotracheal catheter application, and a combination application of these two catheters separately in tracheotomy patients. *Method.* A study was carried out on 85 patients with a metal catheter from 1990 to 1997, 62 patients with a disposal endotracheal catheter from 1998 to 2002, and 56 patients with an on-vent disposal endotracheal catheter and an off-vent metal catheter from 2003 to November 2008, defined respectively as groups A, B, and C, in order to observe catheter balloon rupture and catheter olisthe during intubation, as also sputum adhesion to the endotracheal catheter wall after application, and to assess the number of cases of patients with airway bleeding, the number of patients with endotracheal catheter blockage, and the time lapse between ventilator withdrawal and extubation. *Results.* Patients in groups B and C were observed to have balloon rupture; the number of patients with catheter olisthe and airway bleeding was in both cases less than in group A ($p < 0.05$); and in groups A and C the number of patients with catheter blockage was in both cases less than in group B ($p < 0.05$) - extubation time was also shorter than in group B, but without statistical significance ($p > 0.05$). Macroscopic observation found that there was a large amount of sputum adhering to the lumen of the open disposal endotracheal catheter and that the lumen became significantly narrow, while the metal catheter became non-significantly narrow. *Conclusion.* In inhalation injury patients we found that the effect of the combination application of the disposal endotracheal catheter and the metal catheter was better than that of the single application.

Introduction

At present, endotracheal catheters for tracheotomy are mainly either disposal endotracheal catheters or metal catheters, both with their respective advantages and disadvantages in clinical application.¹ However, there are no reports on the clinical effect of the combined application of an on-vent disposal endotracheal catheter and an off-vent metal catheter. A comparison was made between a single metal catheter application, a single disposal endotracheal catheter application, and a combination application of a metal catheter and a disposal endotracheal catheter in 203 cases of tracheotomy patients who received treatment in our burns centre from 1990 onwards in order to observe the effect of the application and the complications rate in each group, thus providing an objective trial basis for the rational application of such catheters.

Materials and methods

Source of materials

Two hundred and three tracheotomy and mechanically ventilated patients (154 males/49 females; age, 17-56 yr; average burn area, $63.50 \pm 29.27\%$, due to various rea-

sons; third-degree burn area, $28.66 \pm 13.93\%$) with inhalation injury who received treatment from January 1990 to November 2008 in our burns centre were enrolled in the study.

Grouping method

The 203 patients meeting the inclusion criteria were divided into groups A, B, and C. These were, respectively, 85 cases of patients with a metal catheter from 1990 to 1997 (group A); 62 cases of patients with a disposal endotracheal catheter from 1998 to 2002 (group B); and 56 cases of patients with an on-vent disposal endotracheal catheter and an off-vent metal catheter from 2003 to November 2008 (group C). Group A comprised 57 males and 28 females; age, 28.60 ± 10.36 yr, burn area, $43.68 \pm 18.96\%$; burn area, $18.54 \pm 7.30\%$; ratio between moderate and severe inhalation injury patients, 5.3:1. Group B comprised 41 males and 21 females; age, 25.84 ± 11.23 yr; burn area, $38.68 \pm 14.63\%$; burn area, $17.38 \pm 8.78\%$; ratio between moderate and severe inhalation injury patients, 5.0:1. Group C comprised 38 males and 18 females; age, 29.45 ± 15.32 yr; burn area, $39.57 \pm 13.54\%$; burn area, $16.94 \pm 7.36\%$; ratio between moderate and severe inhalation injury patients, 4.3:1. The statistical differences between the three groups as regards sex, age, burn area

and inhalation injury classification, treatment time, and ventilator application time were not significant ($p > 0.05$).

Trial method

Group A used a balloon-attached metal catheter (Xinxiang City Tuoren Medical Device Co., Ltd), Group B a disposal endotracheal catheter (Xinxiang City Tuoren Medical Device Co., Ltd.), and Group C an on-vent disposal endotracheal catheter + an off-vent metal catheter; the inner catheter of the metal catheter could be pulled out for cleaning and disinfecting four times a day. The purpose was:

- * to calculate the number of patients with airway bleeding during intubation (the judgement standard for bleeding was a single bloody sputum of more than 2 ml or, failing that, two or three consecutive bloody sputum aspirates;
- * to calculate the time from ventilator withdrawal to extubation - the standards for ventilator withdrawal and extubation were: $R < 30$ beats/min, PO_2 80 mm Hg, PCO_2 45 mm Hg, easy breathing;
- * to observe sputum adhesion on the catheter walls after extubation;
- * to calculate the number of cases of catheter balloon rupture and catheter olithe in patients in each group;
- * and to observe the number of cases of catheter replacement due to endotracheal catheter blockage during intubation.

Statistical methods

SPSS 15.0 statistical software was used to perform the t test and χ^2 test analysis on the data, which were expressed as $\bar{x} \pm s$. The test criterion was $p = 0.05$; $p < 0.05$ represented a difference having statistical significance.

Results

The number of patients with balloon rupture, catheter olithe, and airway bleeding in groups B and C was always less than that in group A ($p < 0.05$), while the number of patients with catheter blockage in groups A and C was in both cases less than in group B ($p < 0.05$); here, extubation time was also shorter than in group B, but without statistical significance ($p > 0.05$) (Table I).

The extubated metal catheter wall was not observed to have any visible sputum scabs attached to it. However, the disposal endotracheal catheter was found to have visible thick sputum scabs attached to it - the most sputum scab-attached partial lumen narrowed by one-third in its inner diameter.

Discussion and conclusion

Currently, inhalation injury is the leading cause of death by burns, and effective treatment for inhalation injury patients has important clinical significance for the reduction of burns mortality.² One effective way of saving inhalation injury patients is to perform early tracheotomy and reasonably timely application of a ventilator,³ although complications may occur in the clinic after tracheotomy.⁴ The prevention and treatment of such complications is an ever-present issue that clinicians have to deal with. Cleaning out foreign bodies and secretions in the airway is an important procedure throughout the treatment of inhalation injury, with the purpose not only of keeping the airway open, preventing atelectasis and maintaining good ventilation, but also of cleaning the airway, reducing infection, promoting the early healing of erosive mucous membrane and ulceration, and reducing complications.⁵ As a result, one key treatment question is how to effectively clear out secretions and foreign bodies in the airway so that the injured airway mucosal membrane can heal quickly, a question to which the application of endotracheal catheters is closely related.

Before 1998, our Department often used a metal catheter, successfully treating a large number of patients with inhalation injury. However, this method involved attaching a balloon when connecting the ventilator, a balloon that easily became detached because of poor fixation. It was also hard to determine the exact air volume to inject into the balloon, with the result that excessive air pressure led to rupture of the balloon. Given this difficulty, if the air pressure was too great, it pressed on the tracheal wall, resulting in airway mucosal bleeding. As a result, if it was necessary to reduce pressure damage to the tracheal wall, the balloon required deflating every 3-4 hours, which

Table I - Comparison of the trial's statistical results in the different groups

Group (A,B,C)	Balloon rupture and catheter olithe (number of cases)	Severe airway bleeding (number of cases)	Catheter blockage (number of cases)	Time from ventilator withdrawal to extubation (days)
Group A	7 cases of rupture 6 cases of olithe	28 / 5	2	2.6 ± 0.6
Group B	2 cases of rupture	12 / 0	8	4.1 ± 0.42
Group C	1 case of rupture	14 / 1	4	2.9 ± 0.27

Note: In the comparisons between the groups, groups C and B were compared separately to group A ($p < 0.05$), group C was compared separately to groups A and B ($p < 0.05$), and groups A and C were compared separately to group B ($p < 0.05$)

imposed a heavy nursing load. The emergence of disposal endotracheal catheters overcame the deficiencies of metal catheters. Using a disposal endotracheal catheter, balloon pressure can be evenly distributed over the tracheal wall, and non-deflation for a longer period (6-8 h) does not normally lead to mucosal ischaemia necrosis as a result of the pressure. The Centre therefore used a disposal balloon catheter in all on-vent patients from 1998 to 2002. The disposal endotracheal catheter's principal features are its ease of application, the facility of determining the injected air volume, and its reduction of the nursing burden.

However, it was also found in cases of long-term clinical application that the disposal endotracheal catheter did not eliminate sputum without some difficulty and easily became blocked as a result of the inconvenient disinfection procedure¹ and consequently had to be frequently replaced, exposing patients to greater risk. In addition, inhalation injury patients normally require lengthy intubation, while the catheter needed blocking before extubation in order to enhance the patients' respiratory muscle training for extubating as soon as possible. The disposal catheter cannot however be extubated directly, thus prolonging extubation time.

How to make full use of the advantages of the two types of catheters and overcome their shortcomings is a constant issue. Nevertheless, in the past five years, their clinical application in our Centre has proved that the timely combined use of the two catheters can fully outweigh the disadvantages of their single use and has achieved good results. The present study found that the group of patients treated with combined use of the two catheters presented fewer episodes of balloon rupture and olisthe during intubation than the groups treated with their single use. The combination use succeeded in overcoming the problem presented by the balloon being liable to rupture and olisthe when the metal catheter was used singly, and also reduced the number of cases of patients with tracheal bleeding. This in particular could significantly reduce the incidence of fatal tracheal bleeding, and the combination use therefore

has a certain significance for reduction of the mortality rate. The study also found that the combination use of two catheters reduced the incidence of disposal endotracheal catheter blockage, mainly because the metal catheter is convenient to clean and disinfect and is not easily subject to sputum adhesion. During the trial, it was found that there was sputum adhering to the inner wall of the open disposal endotracheal catheter, making the lumen become narrow - in the most serious case the lumen narrowed by nearly two-thirds. The disposal endotracheal catheter is thus not convenient for elimination of sputum. At the same time, it was also found that when adopting the combination use of disposal endotracheal catheter and metal catheter, the extubation time could be reduced by an average of one day, although without statistical significance. In view of the limited size of the sample in this study, the stable effect of the combination application of two catheters still requires observation in a more extensive sample size as well as evidence-based medical evaluation.

Since 2003, the combination application of an on-vent disposal endotracheal catheter and an off-vent metal catheter in patients with protracted intubation requirements (more than 10 days) after ventilator withdrawal in our burns centre has achieved good results, showing positive values for clinical application. However, it is necessary to note that although it is used in the late period of tracheal mucosa injury repair, the metal catheter may come into direct contact with the tracheal wall when swinging, it is not easy to fix, and it can easily cause further injury to the airway mucous membrane. Consequently, during the metal catheter application process, overdrastic action has to be avoided as much as possible in order to prevent any injury to the airway mucous membrane that might cause bleeding. In the present study, application of the metal catheter was limited to a short period, during which time attention was paid to its adverse effects. It was found in the end that the number of cases with tracheal bleeding was not manifestly greater than when using a disposal endotracheal catheter.

RÉSUMÉ. *Objectif.* Le but de cette étude était d'effectuer une évaluation objective de la nature et de l'efficacité scientifique d'une application en combinaison de deux cathéters moyennant une analyse comparative des effets et de la manifestation de complications avec l'application d'un seul cathéter métallique, de l'application d'un cathéter endotrachéal à jeter et de l'application en combinaison de ces deux cathéters séparément dans les patients trachéotomisés. *Méthode.* Quatre-vingt-cinq patients avec un cathéter métallique (période, 1990 à 1997), 62 patients avec un cathéter endotrachéal à jeter (période, 1998 à 2002) et 56 patients avec un cathéter endotrachéal à jeter «on-vent» et un cathéter métallique «off-vent» (période, 2003 à novembre 2008), définis respectivement comme groupes A, B et C, ont été étudiés pour observer la rupture du ballon du cathéter et le glissement du cathéter pendant l'intubation, comme aussi l'adhésion de l'expectoration aux parois du cathéter endotrachéal après l'application, et pour vérifier le nombre de patients atteints d'hémorragie des voies aériennes, le nombre de patients avec obstruction du cathéter endotrachéal, et l'intervalle entre la suspension du ventilateur et l'extubation. *Résultats.* Les patients inclus dans groupes B et C ont subi la rupture du ballon; le nombre de patients avec glissement du cathéter et hémorragie des voies aériennes était inférieur, dans tous les deux cas, au nombre dans le groupe A ($p < 0.05$); et dans les groupes A et C le nombre de patients avec obstruction du cathéter était inférieur, dans tous les deux cas, au nombre dans le groupe B ($p < 0.05$) - le temps de l'extubation était aussi plus court par rapport au groupe B, mais sans signification statistique ($p > 0.05$). L'observation macroscopique a démontré qu'il y avait

une grande quantité d'expectoration sur le lumen ouvert du cathéter endotrachéal à jeter et que le lumen se rétrécissait en manière significative, tandis que le cathéter métallique se rétrécissait en manière non significative. *Conclusions.* Avec les patients atteints de lésions dues à l'inhalation, l'effet de l'application associée du cathéter endotrachéal à jeter et le cathéter métallique s'est démontrée plus efficace que l'effet de l'application simple.

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