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Brief Reports

Physiological Effects of a Spit Restraint Device Saturated With Artificial Saliva

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□ **Abstract—Background: Spit restraint devices, also referred to as spit hoods, spit masks, or spit socks, are used by law enforcement and medical personnel to minimize transmission of communicable disease from bodily fluids from agitated individuals. Several lawsuits have implicated spit restraint devices as contributing to the death of individuals who are physically restrained by means of asphyxiation due to saturation of the mesh restraint device with saliva. Objectives: This study aims to evaluate whether a saturated spit restraint device has any clinically significant effects on the ventilatory or circulatory parameters of healthy adult subjects. Methods: Subjects wore a spit restraint device dampened with 0.5% carboxymethylcellulose, an artificial saliva. Baseline vitals were taken, and a wet spit restraint device was then placed over the subject's head, and repeat measurements were taken at 10, 20, 30, and 45 min. A second spit restraint device was placed 15 min after the first. Measurements at 10, 20, 30, and 45 min were compared with baseline using paired *t*-tests. Results: The mean age of 10 subjects was 33.8 years, and 50% were female. There was no significant difference between baseline and while wearing the spit sock for 10, 20, 30, and 45 min for the measured parameters including heart rate, oxygen saturation, end-tidal CO_2, respiratory rate, or blood pressure. No subject indicated respiratory distress or had to terminate the study. Conclusions: In healthy adult subjects, there were no statistically or clinically significant differences in ventilatory or circulatory parameters while wearing the saturated spit restraint. © 2022 Published by Elsevier Inc.**

□ **Keywords—Spit hood; Spit mask; Spit restraint; Wet spit mask; Wet spit restraint; Mesh hood**

Introduction

The usage of spit restraint devices by law enforcement and medical personnel has increased over the past several years. There have also been increasing concerns raised regarding their safety. A spit restraint device or mask is a loose mesh sack placed over a person's head to minimize transmission of communicable disease if the person is spitting, or blowing their nose, typically while in an agitated state. According to the San Diego Sheriff's Department's Use of Force Statistical Report, spit restraint devices were used 305 times in 2015, and increased to 423 times in 2018, 487 times in 2019, and 391 times in 2020 (1–3). The increase in the use of spit restraint devices in recent years has also led to increased controversy surrounding their use, coinciding with national media coverage regarding alleged police brutality (4). Human rights groups have protested against the use of spit restraint devices, stating they can cause distress, humiliation, and increased risk for asphyxiation (4,5).

In addition to psychological trauma that a spit restraint device can reportedly cause, the controversy surrounding spit restraint devices involves the safety and its effect on adequate ventilation. The proposed mechanism is that spit restraint devices can contribute to asphyxiation and respiratory arrest (6). Some allege that spit restraint devices restrict airflow because the mask becomes saturated from saliva or blood, occluding the mesh holes of the spit restraint device and not allowing for adequate ventilation

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(5). There are allegations of improper use and technique of the spit restraint devices and physical restraints (7). Other allegations include individuals vomiting while wearing a spit restraint device, further contributing to asphyxiation (8).

Currently, literature regarding the safety of spit restraint devices is limited. Two previous studies concluded there were no clinically significant differences in breathing, ventilatory, or circulatory parameters when using two different brands of spit restraint devices of varying thickness in healthy adult individuals (9,10). Although previous studies using dry spit restraint devices have been important in understanding the impact of spit restraint devices in general, we believe further studies need to be performed for masks obscured by fluid. There has been no wet spit restraint device study to date. A wet spit restraint device is a more reasonable simulation of a true field event where a spit restraint device is needed. This study seeks to assess the effect on physiologic parameters, specifically ventilation, that a spit restraint device has when saturated with artificial saliva.

Methods

Study Design

This was a prospective study evaluating the changes in vitals and ventilation in healthy adult volunteers wearing a wet spit restraint device dampened with 0.5% carboxymethylcellulose. The study was reviewed and approved by our Institutional Review Board. All participants provided written informed consent.

Study Setting and Population

We performed this study with volunteer subjects at an academic medical center. Inclusion criteria were voluntary individuals between the ages of 18 and 65 years. Exclusion criteria included people who were pregnant, claustrophobic, or had an allergy to carboxymethylcellulose. The study also excluded those who did not feel comfortable continuing in the study or participating at any time.

Study Protocol

Prior to the subjects' arrival, we made 0.5% carboxymethylcellulose (CMC) solution using standard technique by dissolving 5 grams of commercially available dry CMC powder into 1000 mL of deionized water at 25°C. The preparation of this solution has previously been published as an artificial saliva that is used for patients who have removed or nonfunctional salivary glands (11). After participants signed a consent form, we collected descriptive data from subjects, including gender, height, weight, age, and any past medical conditions. The subject was then placed in a seated position in a chair and baseline vitals were taken, including heart rate, respiratory rate, blood pressure, oxygen saturation, and end-tidal CO_2. We placed a buzzer in the subject's dominant hand and the subject was instructed to press the buzzer if the subject were unable to verbalize distress, at which point the spit restraint device would be removed from their head. The inside of the spit restraint device was then dipped in 0.5% CMC solution, covering a 3-inch diameter area near the nose and mouth. The spit restraint device was then placed over the subject's head. The spit restraint device used in this study was the white MTR Spit hood (SKU: MTR-SS285W; Med-Tech Resource [MTR], Eugene, Oregon) (Figure 1). The subject remained under the wet spit restraint device for 15 min, upon which a second dry spit restraint device was placed over the first to simulate the occasional practice of adding a second spit restraint device when the first one becomes saturated, rather than exchanging them.

Repeat vital signs were taken at 10, 20, 30, and 45 min while the subject was wearing the mask(s). The experiment would have ended and the mask(s) removed if the patient indicated distress, their end-tidal CO_2 increased 10 points above baseline, their O_2 saturation dropped below 91%, if the subject pressed the buzzer, or if the heart rate went above 110 beats/min or dropped 10 beats/min below their baseline.

Measures

We measured each subject's vital signs and ventilatory measures, including end-tidal CO_2, oxygen saturation, respiratory rate, heart rate, and blood pressure, at rest prior to application of the spit restraint device to establish a baseline, subsequently after application at 10-, 20-, 30-, and 45-min intervals. Heart rate, oxygen saturation, respiratory rate, and end-tidal CO_2 were obtained using a Smith's Medical Capnocheck II Hand-Held Capnograph/Oximeter (Smith's Medical ASD, Inc., Norwell, Massachusetts).

Data Analysis

We entered data in an Excel (Microsoft Corporation, Redmond, Washington) database for analysis and performed analyses using SPSS Version 28.0 (SPSS Inc., Chicago, Illinois). This study used paired sample *t*-tests to measure differences in means between vital signs at baseline and after wearing the wet spit sock for 10 min, 15 min, 30 min, and 45 min. In our analysis, $p < 0.05$ was considered to represent a significant difference.

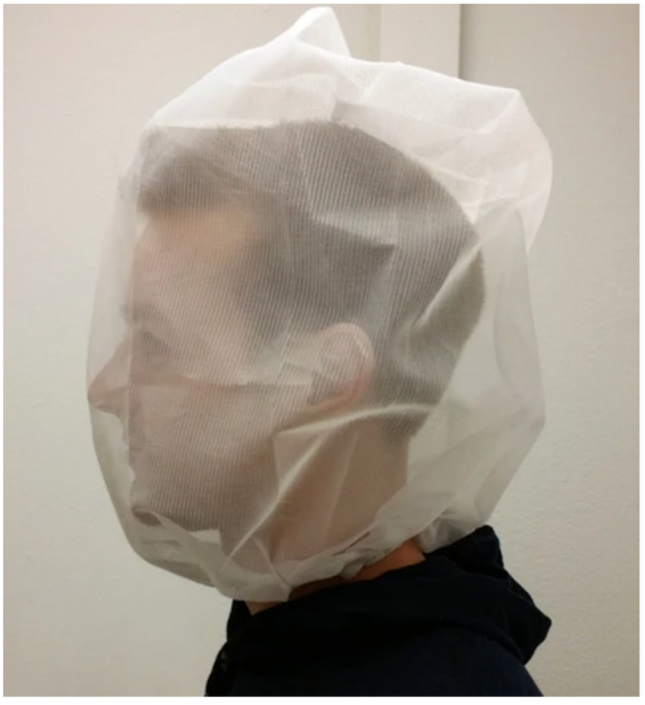

Figure 1. The white Med-Tech Resource (MTR, Eugene, Oregon) spit restraint used in this study.

Table 1. Characteristics of Study Subjects (n = 10)

	Mean (SD)	Range
Age (years)	33.8 (14.6)	19–54
Weight (kg)	73.5 (14.7)	56.7–98
Height (m)	1.72 (0.1)	1.60–1.83
Body mass index (kg/m^2)	24.6 (3.1)	20.5–30.6

Results

Characteristics of Study Subjects

A total of 10 subjects completed the study, of which the mean age was 33.8 years, and 50% were female. No subject was screened out prior to or after consent. One subject reported a medical history of mild intermittent asthma. No other medical conditions were reported. Other subject characteristics are reported in Table 1.

Main Results

Table 2 shows the mean vital signs and ventilatory parameters at baseline without the spit restraint device and at 10-, 20-, 30-, and 45-min intervals after wet spit restraint application. There was no significant difference between baseline and while wearing the spit restraint for 10, 20, 30, and 45 min for systolic blood pressure ($p = 0.106$, $p = 0.411$, $p = 0.946$, $p = 0.240$, respectively), diastolic blood pressure ($p = 0.163$, $p = 0.786$, $p = 0.834$, $p = 0.493$, respectively), heart rate ($p = 0.496$, $p = 0.294$, $p = 0.641$, $p = 0.396$, respectively), respiratory rate ($p = 0.301$, $p = 0.887$, $p = 0.559$, $p = 0.637$, respectively), oxygen saturation ($p = 0.510$, $p = 0.343$, $p = 0.217$, $p = 0.132$, respectively), or end-tidal CO_2 ($p = 0.442$, $p = 0.697$, $p = 0.823$, $p = 0.697$, respectively). No subject indicated respiratory distress or had to terminate the study due to worsening vital signs.

Discussion

Our study found no statistically significant differences in ventilatory or circulatory parameters while wearing a saturated spit restraint mask for 45 min, even after the application of a second spit restraint mask. Spit restraint devices have been used by law enforcement and medical personnel as a safety measure to protect against bodily fluids from individuals that are noted to be agitated or altered. In our study, we found no significant difference between baseline and while wearing the spit sock for the entire study for our measured parameters and vital signs. Spit restraint devices had been utilized by law enforcement personnel and prison guards for decades

Table 2. Effect of a Saturated Spit Restraint on Vital Signs and Ventilatory Parameters (n = 10)

	Baseline	10 Min	20 Min	30 Min	45 Min
Heart rate (beats/min)					
Mean (SD)	68.1 (12.4)	70.0 (11.5)	71.1 (14.8)	69.9 (10.6)	72.6 (13.4)
Change from baseline (SD)	/	1.9 (8.5)	3.0 (8.5)	1.8 (10.9)	4.5 (16.0)
95% CI	/	−4.2–8.0	−3.1–9.1	−6.0–10.0	−7.0–16.0
p-Value	/	0.496	0.294	0.641	0.396
O_2 Sat (%)					
Mean (SD)	97.2 (1.2)	96.6 (1.1)	97.0 (1.1)	96.6 (0.8)	96.5 (1.2)
Change from baseline (SD)	/	−0.6 (0.8)	−0.2 (0.6)	−0.6 (1.4)	−0.7 (1.3)
95% CI	/	−1.2–0.0	−0.7–0.3	−1.6–0.4	−1.7–0.3
p-Value	/	0.51	0.343	0.217	0.132
$EtCO_2$ (mm Hg)					
Mean (SD)	36.0 (2.4)	36.7 (1.9)	36.3 (2.6)	35.8 (2.9)	36.3 (2.8)
Change from baseline (SD)	/	0.7 (2.8)	0.3 (2.4)	-0.2 (2.7)	0.3 (2.4)
95% CI	/	−1.3–2.7	−1.4–2.0	−2.2–1.8	−1.4–2.0
p-Value	/	0.442	0.697	0.823	0.697
RR (breaths/min)					
Mean (SD)	14.5 (4.9)	13.3 (3.4)	14.7 (3.8)	13.5 (5.6)	15.3 (3.9)
Change from baseline (SD)	/	−1.2 (3.5)	0.2 (4.3)	−1.0 (5.2)	0.8 (5.2)
95% CI	/	−3.7–1.3	−2.9–3.3	−4.7–2.7	−3.0–4.6
p-Value	/	0.301	0.887	0.559	0.637
SBP (mm Hg)					
Mean (SD)	126.8 (14.1)	119.2 (17.7)	128.6 (17.2)	126.5 (23.2)	121.8 (18.7)
Change from baseline (SD)	/	−7.6 (13.4)	1.8 (6.6)	−0.3 (13.7)	-5.0 (12.6)
95% CI	/	−17.2–2.0	−2.9–6.5	−10.1–9.5	-14.0, 4.0
p-Value	/	0.106	0.411	0.946	0.24
DBP (mm Hg)					
Mean (SD)	79.6 (9.5)	74.1 (19.7)	78.9 (14.4)	80.3 (14.3)	81.6 (12.3)
Change from baseline (SD)	/	−5.5 (11.4)	−0.7 (7.9)	0.7 (10.3)	2.0 (8.8)
95% CI	/	−13.7, 2.7	−6.4–5.0	−6.7–8.1	−4.3–8.3
p-Value	/	0.163	0.786	0.834	0.493

SD = standard deviation; CI = confidence interval; $EtCO_2$ = end-tidal CO_2; RR = respiratory rate; SBP = systolic blood pressure; DBP = diastolic blood pressure.
p-Values and CI are given for comparison between baseline and indicated time after spit sock application.
*Significant difference between baseline and after spit sock application ($p < 0.05$).

but increased in use during the 1980s due to the AIDS pandemic (12). Since the appearance of severe acute respiratory syndrome coronavirus 2 (SARS CoV-2), there has been a growing demand for such devices, as well as expanding policies on personnel allowed to use spit restraint devices to include emergency medical services and patrol officers (6). Although spit restraints are an effective method of preventing the transmission of bodily fluids, spit restraints have been featured more in the news with increased controversy surrounding their use, coinciding with national media coverage regarding alleged police misconduct (4). Human rights groups have protested the use of spit restraint devices, stating they can cause distress, humiliation, and increase risk for asphyxiation (4,5). Critics claim that the spit restraint device is degrading, citing the historical implication that spit restraint devices were used in the past specifically with prisoners and "torture chambers," and has led to several lawsuits, including a recent case where a 12-year-old boy was placed in a spit restraint device and traumatized (5,12,13).

Furthermore, spit restraint devices have been implicated in multiple high-profile in-custody deaths, most notably in New York, Arizona, California, Michigan, and the United Kingdom (5–8). Several wrongful death law-

suits have implicated spit restraint devices as contributing to the death of individuals that are physically restrained by means of asphyxiation due to saturation of the mesh restraint device with saliva or other bodily fluids, leading to decreased airflow (5).

For example, in Rochester, New York in 2020, an agitated man under the influence of phencyclidine was placed in a spit restraint device by police officers, noted to be spitting while in the spit restraint and, later, vomiting (5,12). He became unresponsive and went into cardiac arrest, dying 1 week later with concerns raised about the spit restraint leading to complications of asphyxiation (5). Some suggest that lack of protocol and training regarding the use of a spit restraint device on an individual, particularly if the individual is spitting or vomiting, contributed to a wrongful death (12).

Prior studies have evaluated the use of other spit restraint devices and concluded there were no clinically significant differences in breathing, ventilatory, or circulatory parameters in healthy adults (9,10). The goal of this experiment was to address some of the limitations of the prior studies and attempt to simulate a more realistic event where a spit restraint device may become saturated with saliva. This study demonstrated no significant changes in any ventilatory or circulatory parameters, including heart rate, respiratory rate, oxygen saturation, end-tidal CO_2, and systolic and diastolic blood pressure, while wearing one wet spit restraint device. Additionally, there were no significant changes in any ventilatory or circulatory parameters when the subjects were placed in a second, dry spit restraint device 15 min after the application of the first wet spit restraint.

Limitations

This is a small study of 10 subjects, and a larger number of subjects would be needed to obtain higher statistical significance. Additionally, all subjects studied were healthy volunteers without significant comorbid conditions, and all female subjects were not pregnant. This study was performed while patients were sitting at rest, and subjects in the field that are placed in spit restraint devices may be agitated, often with abnormal vital signs. In true field or hospital events, most subjects have additional factors that can contribute to distress, including but not limited to, illicit substance ingestion, claustrophobia, or other medical or mental health conditions that can increase anxiety and disorientation while wearing a mask. Although this study attempted to simulate a more realistic event by studying physiological effects of wet spit restraint devices, we did not replicate other circumstances that may be present in certain cases, including when a patient is agitated, restrained on the ground, potentially injured, or when other bodily fluids are contaminating a spit restraint device, such as blood or emesis. Additionally, we studied one brand of spit restraint device. There is no industry standard when it comes to manufacturing spit restraint devices, so the effects of spit restraint devices on ventilation can vary with different brands (8–10). Lastly, additional data are needed regarding the use of spit socks in the emergency department. Although training is likely provided in the emergency department on proper use and application of spit socks, there is limited information to confirm this and there may be differences in how this information is prescribed per institutional standards.

Conclusion

In healthy subjects, there were no clinically significant changes in the physiologic parameters of ventilations while wearing a wet spit sock. Further research is needed to test other ventilatory and circulatory parameters of spit socks with subjects in different positioning, alternative masks, during physical exertion, and the effects of thicker, more occlusive bodily fluids such as blood or emesis.

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ARTICLE SUMMARY

1. Why is this topic important?

Spit socks are frequently used with agitated patients in a variety of situations for the protection of personnel in the prevention of droplet-spread infections. It is important to understand whether the use of spit socks in these situations may impact patient safety.

2. What does this study attempt to show?

This study aims to demonstrate the safe use of spit socks for agitated patients.

3. What are the key findings?

Spit socks do not impact physiological parameters such as ventilation in healthy adults.

4. How is patient care impacted?

Health care and other personnel can safely use spit socks on agitated patients to prevent the spread of infection via bodily fluids.