



## Simulation and education

## Do bulb syringes conform to neonatal resuscitation guidelines?☆

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## ABSTRACT

**Objective:** To reduce airway injury secondary to high suction pressures, the American Academy of Pediatrics Neonatal Resuscitation Program (NRP) recommends that suction pressures be less than 100 mm Hg. This study was conducted to determine if suction bulbs conform to these recommendations.

**Study design:** In this prospective in vitro study, 25 personnel involved in neonatal resuscitation squeezed a new bulb three times for each of six commercially available bulbs using their delivery suite technique. A calibrated, pneumatic transducer measured the pressure of each squeeze.

**Results:** Only one bulb met the NRP guidelines with none of the participants exceeding 100 mm Hg ( $p < 0.001$ ).

**Conclusions:** Only one bulb met the NRP guidelines of generating pressures less than 100 mm Hg. This bulb's large size (3 oz) may preclude its use in premature infants. Individuals involved in resuscitating newborns need to be aware of the pressures generated to avoid injuring the delicate oral airway.

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## 1. Introduction

One of the first and foremost steps in neonatal resuscitation is obtaining a patent airway. The current guidelines from the American Academy of Pediatrics' Neonatal Resuscitation Program (NRP) recommend clearing the airway, if necessary with a bulb syringe or suction catheter.<sup>1</sup>

Although it is important to obtain a patent airway quickly by clearing secretions via suctioning, overly aggressive suctioning can lead to potentially fatal injuries to the oral-pharyngeal airway.<sup>2</sup> To reduce this risk, the NRP guidelines recommend that the negative pressure generated from suction apparatus (wall/pump) be less than 100 mm Hg.<sup>3</sup> Even though these guidelines are for continuous wall suction, it is prudent to use the same guidelines for the pressures generated from bulb syringes until safety data specific to bulb syringes are published in the medical literature.

In our own neonatal practice, we have observed the development of nasal obstruction in some infants undergoing bulb suctioning in the delivery room. Upon reviewing the medical literature, we are unaware of any information on the potential negative pressures generated by the bulb syringes commonly used in neonatal resuscitation. Hence, this study was conducted to determine

if the various bulb syringes used by delivery suite personnel conform to the NRP recommendation of generating negative pressures <100 mm Hg.

## 2. Methods

## 2.1. Overview of study design

In this prospective, in vitro study, 25 hospital personnel involved in neonatal resuscitation squeezed six different bulb syringes using the same technique that they use in the delivery suite. A calibrated, pneumatic transducer determined the negative pressure generated from each squeeze.

## 2.2. Study personnel

Twenty-five newborn care providers including neonatal and labor and delivery nurses, respiratory therapists, and neonatologists participated in this study. The study was approved by the Institutional Review Board for Human Investigation at York Hospital. Verbal assent was obtained from each of the participants.

## 2.3. Equipment

After surveying local hospitals in central Pennsylvania, we identified six bulb syringes that were commercially available to us: Bard 1, 2, and 3 oz syringes (CR Bard, New Providence, NJ); Medline 2 and 3 oz syringes (Medline Industries Inc., Mundelein, IL) and Cardinal 2 oz bulb syringe (Cardinal Health, Dublin, OH).

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Fig. 1. Equipment used for measuring negative pressures generated by bulb syringes.

The negative pressure generated by squeezing each bulb was measured with a calibrated, pneumatic transducer (Model DPM-IB, BIO-TEK Instruments Inc., Winooski, VT). This device is used in calibrating hospital wall suction units and has an accuracy of within 1 mm of Hg. To determine the negative pressure generated from each squeeze, the pneumatic transducer inlet was fitted with two 3-way stopcocks connected in series with the most distal stopcock (from the transducer) attached to the barrel of a 3 ml syringe (Fig. 1). The nozzle of the bulb syringe then was fitted snugly into the barrel of the syringe. The distal stopcock nearest to the transducer is closed to the atmosphere as well as to the proximal stopcock attached to the syringe nozzle. Before the bulb syringe was squeezed, the proximal stopcock was open to the atmosphere to allow the air to escape. While the study subject maintained the squeeze, the proximal stopcock closest to the syringe was turned off to the atmosphere thus preventing the re-expansion of the bulb syringe. The subject then let go of the squeezed bulb. The distal stopcock was opened to the bulb syringe thus allowing the transducer to measure the negative pressure generated by the squeezed bulb. This airtight system permitted a stable negative pressure reading.

#### 2.4. Study design

Each of the study personnel was presented with six new bulb syringes representing one from each of the six types listed above. The subjects were instructed to squeeze the bulb using the same technique that they use in the delivery suite. Each bulb was squeezed 3 times with at least 30 s between each measurement; hence, 18 measurements were recorded for each subject. The study subject was blinded to the results generated from each squeeze. The six different bulb syringes were randomly assessed.

#### 2.5. Data analysis

The data are described using medians as well as the 5th and 95th percentiles for interval data and percentages for nominal data. For interval data, the statistical differences among groups were first assessed with the Kruskal–Wallis test. If the  $p$  value from that analysis was less than 0.05 (two-tail), post hoc comparisons were performed using the Mann–Whitney  $U$  test. The Friedman test was used to determine if there was an effect secondary to repeated squeezing of the bulb. If the  $p$  value from that analysis was less than 0.05 (two-tail), post hoc comparisons were performed using the Wilcoxon signed-rank test. Nominal data were analyzed with

**Table 1**  
Averaged negative pressure generated from each trial of three squeezes.

Bulb	Negative pressure generated <sup>a</sup> (mm Hg, $n = 25$ )	Exceeding 100 mm Hg <sup>**</sup> ( $n = 25$ )
Bard, 1 oz	128.7 (117.4, 169.0) <sup>#,&amp;</sup>	25/25 (100%)
Bard, 2 oz	83.3 (70.8, 140.4) <sup>#</sup>	8/25 (32%)
Bard, 3 oz	97.7 (77.0, 118.7) <sup>#,&amp;</sup>	10/25 (40%)
Cardinal, 2 oz	119.0 (109.6, 146.9) <sup>#,&amp;</sup>	25/25 (100%)
Medline, 2 oz	82.0 (64.7, 99.1)	1/25 (4%)
Medline, 3 oz	78.3 (59.2, 90.7)	0/25 (0%)

Negative pressures are reported as the median with the (5th and 95th percentile).

<sup>a</sup>  $p < 0.001$ , Kruskal–Wallis test.

<sup>\*\*</sup>  $p < 0.001$ , Chi-square test.

<sup>#</sup>  $p < 0.01$ , post hoc comparisons versus Medline 3 oz, Mann–Whitney  $U$  test.

<sup>&</sup>  $p < 0.01$ , post hoc comparisons versus Medline 2 oz, Mann–Whitney  $U$  test.

the Chi-square test. Statistical significance was defined a priori as a  $p$  value  $< 0.05$  (two-tail). However, in order to reduce the risk of test-wise error for the post hoc comparisons, statistical significance was redefined a priori as a  $p$  value  $< 0.01$  for the post hoc comparisons. The data were analyzed using IBM SPSS Statistics Version 20 (IBM Corp., Armonk, NY).

### 3. Results

A total of 25 newborn care providers consisting of registered nurses (neonatal, labor and delivery;  $n = 12$ ), respiratory therapists ( $n = 8$ ) and physicians ( $n = 5$ ) participated in this study. The median years of neonatal intensive care experience for these individuals were 21.0 (2.0, 39.0), 12.5 (2.0, 25.0), and 26.0 (23.0, 29.0) years, respectively.

In squeezing the bulb three times, the replications were similar with the median values from each time period differing at most by 4.0 mm Hg. The suction pressure decreased by 4.0 mm Hg between Time 1 and Time 2 [96.5 (71.0, 155.5) versus 92.5 (67.0, 151.8);  $p = 0.001$ ] and by 2 mm Hg between Time 1 and Time 3 [96.5 (71.0, 155.5) versus 94.5 (64.0, 147.3);  $p < 0.001$ ]. There was no difference between Time 2 and Time 3 ( $p > 0.01$ ). Because of this decrease, the average and highest value of the three replications are reported.

The averaged suction pressures generated by squeezing the bulbs were the highest in the Bard 1 oz followed by the Cardinal 2 oz (Table 1). With these two bulbs, all of the participants generated an averaged negative pressure exceeding 100 mm Hg. The Bard 2 oz and Bard 3 oz bulbs produced suction pressures in the mid-80s and mid-90s with 32% and 40% of the participants exceeding 100 mm Hg, respectively. All four of these bulbs generated higher negative pressures than the Medline 3 oz bulb ( $p < 0.01$ ). The averaged pressures generated from the Medline 2 and Medline 3 oz bulbs were similar with 4% and 0% of the participants exceeding 100 mm Hg, respectively ( $p = 0.091$ ). The Medline 2 oz was similar to the Bard 2 oz bulb ( $p = 0.089$ ) but lower than the Bard 1 and 3 oz as well as the Cardinal 2 oz bulbs ( $p < 0.001$ ).

The highest pressure of the 3 replications in contrast to the individual's averaged value produced similar results except the pressures were slightly higher [range: 4.0 (Medline 2 oz) to 9.3 (Bard 3 oz) mm Hg]. The percentage of individuals with one value exceeding 100 mm Hg were the same as their averaged value except for the Bard 2 oz and Bard 3 oz (increased from 32 to 36% and 40% to 56%, respectively).

### 4. Discussion

In our study, four of the six suction bulb syringes tested generated pressures exceeding 100 mm Hg limit recommended in

the guidelines set forth by the American Academy of Pediatrics NRP.<sup>1</sup> The only bulb syringe (Medline 3 oz) that was consistently below this threshold may be too large to use on premature infants.

For two of the six bulb syringes, all participants generated pressures that exceeded the 100 mm Hg threshold set forth by the NRP. In two of the other bulbs, approximately one-third of the study subjects produced negative pressures that exceeded this guideline. The smallest bulb had the highest pressure; hence, the clinician cannot rely on size as a surrogate for pressures produced from the bulb syringe.

Clinicians may have a tendency to use higher pressures than necessary to achieve the desired effect. In a study involving neonatal resuscitation in the delivery suite, the negative pressure generated by the neonatal personnel using either a 10 French Delee suction catheter or a 3.0 mm internal diameter endotracheal tube was  $157 \pm 34$  and  $176 \pm 58$  mm Hg, respectively.<sup>4</sup> To insure patient safety, practitioners need to be aware of the pressures generated by their equipment and trained according to the current guidelines.

Nasopharyngeal suctioning in the neonate may be associated with a variety of complications ranging from cardiac arrhythmias and apnea to perforations of the hypopharynx. These complications occur more commonly with oral suctioning via a catheter than with a bulb syringe.<sup>5</sup> The traumatic injuries to the hypopharynx and cervical esophagus may mimic esophageal atresia and may lead to respiratory distress (pneumothorax), sepsis (mediastinitis) and upper gastrointestinal bleeding.<sup>2,6,7</sup>

To date there are no published studies regarding suction pressures and oral pharyngeal injury. The potential injury from oral pharyngeal suction pressures may be extrapolated from animal models using endotracheal suctioning. As tracheal suction pressures were increased from 50 mm Hg to 300 mm Hg, the histological changes in a kitten's trachea worsened. At 100 mm Hg, there was loss of epithelium with slight submucosal edema. At 200 mm Hg, there was subepithelial cellular proliferation with fibrinous deposits, and at 300 mm Hg, there was severe damage to both the subepithelial and submucosal layers.<sup>8</sup> In the dog model comparing 100 mm Hg versus 200 mm Hg suction pressure during endotracheal suctioning, more damage to the trachea was noted with using 200 mm Hg of pressure.<sup>9</sup> One may speculate that the mucosal lining of the nasal and oral pharynx coupled with the intermittent nature of bulb suctioning may result in less tissue injury. Until such safety data is published in the medical literature, the conservative approach would be to use the 100 mm Hg guideline for suction pressures for all devices suctioning the upper airway.

Effective suctioning depends on the ability of the device to remove large amounts of viscous material in a timely manner.<sup>10</sup> In an in vitro study, the Bent group evaluated the efficiency of different pressures in removing a fixed amount of meconium-stained fluid instilled into the airway of piglets. In using a 10 French catheter coupled with 5 s of continuous suctioning, the 150 mm Hg pressure in contrast to the  $-80$  mm Hg pressure removed an additional 7.6% of the fluid (83% versus 75.4%, respectively). With the 150 mm Hg pressure, the investigators noticed that visible invagination of the trachea coupled with considerable drag in removing the catheter occurred in contrast to the  $-80$  mm Hg. The clinician will need to decide if the benefit of removing a slightly larger volume of material outweighs the potential risks of mucosal injury from the higher negative pressures.<sup>11</sup> Bulb suctioning of the nasopharyngeal airway is a common procedure in developed countries and may be the only technique available for health care providers in medical facilities of emerging countries without vacuum systems. One may speculate that repeated suctioning of the nares (relatively confined space) coupled with elevated pressures may lead to tissue injury

resulting in nasal obstruction. Because of the associated cardiorespiratory complications of suctioning the nose and mouth, a special report on neonatal resuscitation released in 2010 no longer recommends routine intrapartum oropharyngeal and nasopharyngeal suctioning for healthy infants born with either clear or meconium stained amniotic fluid.<sup>12</sup> When using a bulb syringe becomes necessary, it may be safer to use a bulb that generates recommended pressures.

A potential limitation of our study is that it measured pressures conducted during a simulation in which the participants imitated their technique used during neonatal resuscitations. It is possible that during the stress of an actual neonatal resuscitation, the pressures generated could be higher.<sup>4</sup> In addition, our study evaluated only one aspect of suctioning: compliance with the NRP guideline that suction pressures be less than 100 mm Hg.

## 5. Conclusion

Of the six bulb syringes available commercially, only one consistently met the NRP guidelines of generating suction pressures less than 100 mm Hg. The larger size of this bulb may preclude its use in premature infants. Individuals involved in the resuscitation of newborn infants need to be aware of the pressures generated by their equipment to avoid injuring the delicate tissue of the newborn's oral airway. In addition, further studies are needed to document the complication rates and safety parameters for all procedures, even those that are common medical practices such as bulb suctioning.

## Conflict of interest

The coauthors have no conflicts of interest, nor have they received financial support from any corporate entity.

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