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A Comparison of Respiratory Care Workload With 2 Different Nebulizers

Edward R Hoisington RRT, Robert L Chatburn RRT-NPS FAARC, and James K Stoller MD MSc FAARC

Aerosol therapy via small-volume nebulizer (SVN) accounts for a large proportion of the respiratory care workload. Treatment time is mostly nebulization time, which is highly variable, depending on SVN design. We studied the workload effect of adopting a faster nebulizer. We hypothesized that time saved by faster SVN treatment can be used by respiratory therapists for other patient-care activities. METHODS: We compared day-shift workload distribution in a post-thoracic-surgery ward during 2 consecutive 30-day periods. To deliver bronchodilators (3 mL unit dose), during the baseline period we used the VixOne nebulizer (average nebulization time 9 min), and during the intervention period we used the NebuTech HDN (nebulization time limited to 3 min). We recorded the per-shift number of various respiratory-therapy procedures, which have been assigned standard treatment times, and compared the per-shift numbers of procedures during the baseline and intervention periods. RESULTS: The per-shift number of procedures were similar during the baseline and intervention periods (33.8/shift vs 33.3/shift, $P = .68$), as was the per-shift number of SVN treatments (11.9/shift vs 11.8/shift, respectively, $P = .81$). The per-shift time required for the procedures was greater during the baseline period (4.7 h vs 3.6 h, $P < .001$). The per-shift time available to deliver optional value-added respiratory therapies was higher in the intervention period (0.75 h vs 0.50 h, $P < .04$). The time savings from the faster nebulizer corresponded to 1.8 full-time equivalents and theoretical net annual savings of $66,491. We did not use treatment "stacking" (ie, simultaneous administration of SVN treatments to multiple patients). CONCLUSIONS: The NebuTech HDN substantially reduces SVN-administration time, without adverse effects or events, and the time savings were used for value-added patient-care activities. Shorter treatment times can play a role in coping with the national shortage of qualified respiratory therapists. *Key words: aerosol, nebulizer, respiratory care, workload, treatment time, respiratory therapy, respiratory therapist*.
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Introduction

The administration of aerosol therapy via small-volume nebulizer (SVN) accounts for a large proportion of the in-patient respiratory-therapy workload in large health-care organizations. For example, at the Cleveland Clinic, time spent delivering SVN treatments accounts for approximately 40% of the clinical workload outside of the intensive care units.

The time necessary to administer an SVN treatment depends mainly on the aerosol output rate and the volume of the medication administered.[1] Thus, modification of the nebulizer equipment to deliver drug more rapidly could have an important effect on the workload requirements to administer SVN therapy. The purpose of this study was to compare the workload requirement with a common SVN to that with a newer nebulizer that can deliver a standard

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Table 1. Standard Times for Scheduled Patient-Care Activities

Procedure	Standard Time (h)	Standard Time (min)	Type	Description
SVN	0.150	9	Ordered	Administer aerosol via SVN
MDI	0.100	6	Ordered	Administer aerosol via MDI
Bronchopulmonary hygiene	0.167	10	Ordered	Airway-clearance therapies
Positive expiratory pressure therapy	0.167	10	Ordered	Positive expiratory pressure therapy for airway clearance
Incentive spirometry	0.083	5	Ordered	Incentive spirometry
Tracheal suctioning	0.133	8	Ordered	Tracheal suctioning
Nasotracheal suctioning	0.133	8	Ordered	Nasotracheal suctioning
Desaturation study	0.333	20	Optional	Titrate ambulatory F_{IO_2} via pulse oximetry to evaluate need for home oxygen
Noninvasive ventilation	0.500	30	Ordered	Noninvasive mechanical ventilation
Antibiotic aerosol	0.250	15	Ordered	Administer antibiotic aerosol
Arterial-blood-sample collection	0.250	15	Ordered	Arterial puncture for blood sample
Intermittent positive-pressure breathing	0.150	9	Ordered	Intermittent positive-pressure breathing
Bedside spirometry	0.133	8	Ordered	Bedside spirometry for clearance for surgery
Titrate F_{IO_2}	0.067	4	Ordered	Titrate resting F_{IO_2} via pulse oximetry
Tracheostomy-tube change	0.333	20	Ordered	Change tracheostomy tube per department guidelines
Sputum-induction	0.250	15	Ordered	Sputum-induction
Tracheostomy care	0.250	15	Ordered	Per-shift tracheostomy care
Rounds	0.500	30	Optional	Attend physician-led patient rounds
Assessments	0.250	15	Optional	Assess respiratory status change
Patient education	0.250	15	Optional	Review written patient-education handouts with patients/caregivers

SVN = small-volume nebulizer treatment
MDI = metered-dose inhaler treatment
F_{IO_2} = fraction of inspired oxygen

dose of bronchodilator in less time.[2] The specific hypothesis we examined is that the time saved on aerosol workload could be used to increase the time available to spend on other valued RT patient-care activities.

Methods

The study was approved by the Cleveland Clinic's institutional review board.

We compared respiratory care workload during 2 intervals. During the baseline period (March 14, 2007, to April 13, 2007) we used a standard nebulizer (VixOne, Westmed, Tucson, Arizona). During the intervention period (April 14, 2007, to May 13, 2007) we used a newer nebulizer with a higher aerosol output (NebuTech HDN, Salter Labs, Arvin, California). Each study interval comprised 30 consecutive 8-hour day shifts. All nebulizer therapies were administered by one group of 8 RTs, in one post-thoracic-surgery ward. Bronchodilators (3 mL unit dose of albuterol or levalbuterol) were typically administered 3 times a day, under physician orders that endorsed a respiratory care plan generated by our respiratory-therapy consult service, to optimize allocation of treatments.[3,4] All patients ordered to receive bronchodilator via SVN were considered for inclusion in the study. The only patients excluded were those who were unable to tolerate SVN treatment.

The primary outcome variable, cumulative treatment time (in hours), was calculated based on the standard times allocated for each type of patient-care activity (Table 1) and the number of each activity performed during the 8-hour shift. The standard treatment times were derived from previous time and motion studies at Cleveland Clinic. We divided the workload into 3 categories: workload associated with SVN bronchodilator treatments; workload for all other physician-ordered treatments; and workload for desired but less time-sensitive procedures (eg, desaturation studies, respiratory-therapy consult service assessments).[4]

Based on our own bench observations, the standard SVN treatment time with the VixOne is 9 min, and that of the

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Table 2. Data Summary for the Baseline and Intervention Periods

	Median Daily Total					
	Baseline Period			Intervention Period		
	Procedures (*n*)	Time (h)	% Time	Procedures (*n*)	Time (h)	% Time
SVN	358	54	39	353	18	17
Other ordered procedures	624	72	52	592	68	64
Optional procedures	32	13	9	54	20	19
Total	1,014	139		999	106	

SVN = small-volume nebulizer treatment

NebuTech HDN is 2.5 min. During the intervention period, RTs recorded actual treatment times (ie, beginning of nebulization to first sputter) to clinically test our bench observations.

To confirm and extend our observations from the baseline and intervention periods, we also considered a follow-up period 6 months later (July 23, 2007, to September 28, 2007), during which we measured workload (number of SVN treatments and other RT procedures) on 2 randomly sampled days per week over the 10-week period on all wards of the Cleveland Clinic Hospital. For this follow-up period, we calculated the SVN workload as the product of the number of nebulizer treatments and the standard treatment times (as above). The workload of non-SVN procedures was calculated as the product of the number of other procedures and the aggregate standard time allocated for those procedures (8.3 min, which we estimated as the combined time for other procedures from the baseline and intervention periods, divided by the combined number of other procedures in those periods, which yielded an average time per other procedure). Then, with the workload data from the follow-up period we evaluated the effect of a hypothetical 3-min treatment time (if we had used the NebuTech-HDN) versus the 9-min standard time for nebulizer treatment on overall work time and staffing requirements.

We compared the mean numbers of total daily procedures and SVN treatments in the baseline and intervention periods with Student's *t* test. We compared the median total daily procedure times with the Mann-Whitney rank sum test. We compared proportions with the chi-square test. P values $\leq$ .05 were considered statistically significant.

Results

The RTs timed the nebulizer treatments, which allowed us to calculate a clinician-adherence rate to the 3-min treatment time allocated for the NebuTech HDN. Eighty-two percent of the NebuTech HDN treatments were administered in $<$ 3 min, and 18% exceeded 3 min. In a random sample of 42 treatments, the mean $\pm$ SD treatment time was 2.99 $\pm$ 0.14 min. We did not measure clinician-adherence to the 9-min treatment time standard for the VixOne, because we had previously validated it with time-motion studies.

Table 2 shows the numbers and total treatment times of the procedures. The daily number of procedures in the baseline period (33.8/shift) was similar to that in the intervention periods (33.3/shift, P = .68), as was the mean daily number of SVN treatments (11.9/shift during the baseline period vs 11.8/shift during the intervention period, P = .81). However, the daily time required for RTs to administer therapies was higher in the baseline period (4.7 h) than in the intervention period (3.6 h, $P <$ .001) because of the reduced SVN treatment time. Also, the percent of the total respiratory-therapy work time spent administering SVN treatments was significantly lower in the intervention period (16% vs 38%, $P <$ .001), as was the median total daily time SVN-administration time (1.8 h vs 0.6 h, $P <$ .001). Importantly, these time savings were achieved with no treatment "stacking" (ie, simultaneous administration of treatments to different patients) during the intervention period.

As shown in Table 2, the total time (for the period) available to administer "optional" and less-time-sensitive respiratory-therapy procedures (eg, ambulatory desaturation measurements, patient assessments, and tracheostomy care) was significantly greater in the intervention period (0.75 h) than the baseline period (0.50 h, $P <$ .04), which supports our hypothesis that the SVN treatment time saved by the faster nebulizer could be used for those optional activities.

There were no adverse events associated with the nebulizer treatments in either study period. In talking with patients who received nebulizer treatments with the NebuTech HDN and who had previously received nebulizer treatments with conventional nebulizers, the RTs got the impression that the patients preferred the shorter treatment time, but we made no formal survey of patient preference.

Table 3. Work-Load Data From the Follow-up Period

Hospital Area	9-Minute Aerosol Treatment				3-Minute Aerosol Treatment			
	Work Time (min)			Assignments (target = 300)	Work Time (min)			Assignments (target = 300)
	SVN Aerosol	Other RT Procedures	Total Time		SVN Aerosol	Other RT Procedures	Total Time	
G70	18	27	45		6	27	33	
G71	5	16	20		2	16	17	
G81	51	79	130		17	79	96	
G90	28	54	82	277	9	54	63	
G91	42	50	93		14	50	64	274
G110	220	283	503	596	73	283	356	
G111	132	132	264		44	132	176	
H50	11	51	62	326	4	51	55	
H51	31	42	73		10	42	52	
H60	15	46	62		5	46	51	334
H61	8	14	22		3	14	17	
H63	5	30	35		2	30	32	
H70	10	51	61		3	51	55	
H71	8	61	69	322	3	61	64	
H80	66	68	134		22	68	90	257
H81	69	78	147	281	23	78	101	
P	0	0	0		0	0	0	
M50	3	6	9		1	6	7	
M53	21	35	55		7	35	42	
M60	24	32	55		8	32	40	
M63	5	8	13		2	8	9	
M71	29	16	45		10	16	26	
M80	24	36	61		8	36	44	
M81	1	3	4	242	0	3	3	272
Total	825	1,218	2,043		275	1,218	1,493	
Staff required (full-time equivalents)			6.8				5.0	
Potential staff savings			Not applicable				1.8	

Table 3 describes the follow-up period. We calculated SVN-treatment workload as the product of the average number of SVN treatments (in the follow-up period) and either 9 min or 3 min as the standard SVN treatment time. The workload for other respiratory therapies was the product of the average number of other therapies and the 8.3-min average time for other procedures. Then we summed the workload from several wards to provide a hypothetical assignment; the target was 300 min (eg, 277 min for G70 through G90). The assignments for wards G91 and G110 total 596 min and would be shared by 2 RTs. The required staff (eg, 6.8 full-time equivalents) is the sum of the ward total workload divided by the ideal assignment workload of 300 min.

Table 3 shows that if we had used the NebuTech HDN, a hypothetical reduction of nebulization time from 9 min at baseline to 3 min with the NebuTech HDH would allow a reduction in total respiratory staff required to administer ordered respiratory therapy treatments by 1.8 full-time equivalents. Assuming an average hourly wage of $21.00 (not including benefits) the annual time savings from the faster nebulizer is $78,839. We use 4,900 SVNs per year. The VixOne costs $0.66 (annual cost $3,234). The NebuTech HDN costs $3.18 (annual cost $15,582, which is $12,348 more than the VixOne). We subtract the higher cost of the NebuTech HDN ($12,348) from the time savings ($78,839), and the theoretical net annual savings from the NebuTech HDN is $66,491.

Discussion

Our primary finding is that the reduced SVN treatment time gave the RTs more time for other duties. Theoretically, the faster nebulizer saves 1.8 full-time equivalents, and the net savings substantially outweighs the higher cost of the faster nebulizer (net annual savings $66,491). There were no adverse effects or events with the faster nebulizer, nor was the faster nebulizer associated with any changes in clinical procedures (eg, stacking SVN treatments) that could increase the risk of adverse effects or events. Our RTs do not usually stack treatments, but stacking is said to occur during periods of heavy workload.

Our assumption that the faster nebulizer would provide workload benefits depends on the degree to which the time recovered would be used for other RT tasks. Also, a more detailed financial analysis of the adoption of the faster nebulizer would include additional revenue generated by RT activities conducted during the time saved by the faster nebulizer. That analysis was beyond the scope of this study, so arguments in favor of the faster nebulizer must be articulated in terms of enhanced efficiency and better allocation of RT services, rather than in pure cost savings. However, in other settings, a reduced workload may translate to a reduced need to hire for vacant RT positions, which could be important in coping with the national shortage of qualified respiratory therapists. and might lower costs.

Limitations

We studied only single-bronchodilator SVN treatment times (eg, albuterol alone). We did not consider nebulizer treatments with combined drugs (eg, albuterol plus ipratropium) or other drugs (nebulized antibiotics). Our historical data indicate that such "complex" nebulizer treatments compose about 45% of total nebulizer treatments. If we had extended our study to those complex treatments, the benefits of faster nebulization could have been greater.

This study was conducted in only one center, so our conclusions about the benefits of the faster nebulizer require validation at other centers. Also, our study lacked any formal assessment of the clinical efficacy of, or patient preferences about, faster nebulization. Our informal queries to patients suggested that they prefer the shorter treatment time, but some patients may prefer their usual treatments. Formal assessment of patients' subjective experience with the NebuTech HDN is needed.

Though we did not observe any adverse effects during the intervention period, the study was not designed to examine the effects of a shorter treatment time.

There are other aerosol-delivery methods that are faster than the VixOne nebulizer (eg, powder inhaler), but our intent was only to evaluate one means of decreasing SVN treatment time that did not involve changing physician ordering practice or RTs' skill set.

Conclusions

Faster aerosol delivery benefits RT workload and lowers costs. Our study invites further assessment to test the generalizability of that conclusion and to broaden the assessment of faster aerosol administration (eg, regarding patient preferences, combining nebulizer medications, and associated clinical outcomes).

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